The Journal of Parasitology

Volume 10 DECEMBER, 1923 Number 2

SOME NEW AND LITTLE KNOWN NEMATODES *

A. C. Walton

In the course of a series of investigations carried on at the University of Illinois during 1922-23, the writer has had the opportunity of collecting and studying a large number of local Nematode species and here takes the occasion of describing some of the new species and of recording a number of new host and locality records for others. I wish here to express my appreciation to Dr. Henry B. Ward, Director of the Zoological Laboratories of the University of Illinois, not only for the facilities afforded by the Laboratory, but also for his direction in the completion of this work.

Nematospira turgida gen. et sp. nov.

Material of this nematode was obtained from the pyloris and duodenum of field mice caught in Urbana during the fall of 1922. While alive, the parasites are brick-red in color, coiled in a tight spiral (Figs. 4, 14), and lie in the mucus covering the interior of the pyloric stomach and intestine. The worms are very slender, the male being 4 to 6 mm. long and 0.09 mm. in diameter, while the female is 12 to 15 mm. in length and 0.12 to 0.18 mm. in diameter. The body of the male tapers slightly both ways from the middle while that of the female tapers toward the head end only. The cuticula is longitudinally striated over most of the body, showing 30 to 36 prominent longitudinal ridges with 4 to 5 fine striations between each of the larger rows (Figs. 2, 5, 8). The cuticula is inflated in the head region to form two lateral wings of the type shown as a unilateral structure in Warrenius. These wings are transversely striated, as is the body as far back as the excretory pore. There is a constriction in the cuticula just posterior to these wing-like expansions.

The cephalic end is smoothly rounded (Figs. 2, 5) and about 0.03 mm. in diameter in both sexes. The mouth is surrounded by three very poorly defined lips. A buccal capsule is absent and the mouth opens directly into the esophagus. This is straight, very slender, and tapers gradually toward the cephalic end. It is 0.25 to 0.30 mm. in

* Contributions from the Zoological Laboratory of the University of Illinois, under the Direction of Henry B. Ward, No. 226.

length in the male and 0.66 to 0.70 mm. in length in the female, with a maximum diameter of 0.07 to 0.75 mm. The esophagus is eccentric in position, being partially embedded in glandular cells. It is definitely trifid in structure. The intestine is a straight tube, opening through a short, cuticula-lined rectum to a transverse anus which is flush with the surface of the body and located approximately 0.17 mm. from the tip of the tail in the female. A sheath of large glandular cells (Fig. 8) extends along the anterior two-thirds of the intestine. The nerve ring surrounds the esophagus about 0.15 mm. from the tip of the head in the male and 0.30 mm. in the female. The excretory pore opens about 0.25 mm. from the tip of the head in the male and 0.55 mm. in the female, passing obliquely inward and caudad. The two lateral cervical papillae are slight and not very conspicuous, with their tips pointing caudad. They are placed opposite the largest portion of the esophagus, just caudad to the opening of the excretory system. Prebursal papillae are absent.

The testis is a single, slightly convoluted tube running cephalad along the intestine, opening into a double seminal vesicle and a vas deferens which turns caudad at the level of the esophageal bulb and passes back to the cloaca as a highly coiled tube. The cement gland is rather long and is pierced for its entire length by the vas deferens. The ovary is unpaired, and lies posteriorly in the body, giving rise to a greatly convoluted oviduct which passes anteriorly to the level of the esophageal valve before doubling back to the almost terminal vulva. The oviduct swells to form a seminal receptacle before forming the uterus. This latter ends in a muscular ovejector which empties through a short, cuticula-lined vagina. The lips of the vulva are not raised above the surface of the body. The vulva is transverse and lies in the mid-ventral line 0.3 mm. from the tip of the tail, 0.12 mm. in front of the anus. The male bursa (Figs. 22, 24) is closed all around, the dorsal and lateral lobes being practically undifferentiated. The ventro-ventral and the latero-ventral rays have a common base, but with the tips separated and the former turned more sharply forward. The lateral rays have a common base which turns posteriorly from the base of the ventral rays, and splits into three branches. The tip of the ventro-lateral is turned slightly forward, the tip of the medio-lateral ray is almost perpendicular to the edge of the bursa and that of the dorso-lateral is pointed posteriorly and dorsad. The externo-dorsal ray arises at the base of the lateral rays and passes with a slight forward curve almost to the edge of the bursa. The dorsal ray is double, very slender, short, and rises from the bases of the externo-dorsals, passing inwards at a slight angle. The dorsal lobe is really supported by the

two closely adjacent externo-dorsals rather than by the true dorsals. The dorsal lobe is scarcely distinguishable in outlines from the lateral lobes.

The genital cone is a small structure protruding from the floor of the bursa, and having at its apex the opening of the cloaca. No cloacal papillae were distinguishable. The spicules are equal and similar, 0.54 mm. in length, very slender, curved, and somewhat twisted, with a distinct groove along the ventral surface. The accessory piece is small and indistinct. The tail of the female is slender, extending 0.175 mm. back of the anus. It ends bluntly and has no caudal papillae. The ova are still segmenting when deposited. They are thin-shelled, slightly ruggose, and measure 80 by 50μ.

Habitat:—Stomach and duodenum of the field mouse, *Microtus arvalis,* Urbana, Illinois. Type material in the Parasitological Collection of the Zoology Department, University of Illinois.

The Strongyloidea Weiland is divided into six families, and the Trichostrongylidae Leiper, to which the above described form belongs, consists of two sub-families, the Trichostrongylinae Leiper and the Heligmosominae Travassos, separated on the basis of an unpaired system of reproductive organs in both sexes of members of the latter group. The Trichostrongylinae contains fifteen genera and the Heligmosominae six, of which four—Heligmosomum Railliet and Henry, Heligmostrongylus Travassos, Viannaia Travassos and Viannella Travassos—are well established, and two—Warrenius Hall and Citellinema Hall—are doubtful; Travassos (1921) tentatively suggesting their synonomy with Heligmosomum and Viannella, respectively.

The worm described in this paper falls in the sub-family Heligmosominae because of the possession of but a single ovary and oviduct by the females. On the basis of the presence of filiform spicules, prominent longitudinal markings and posteriorly placed vulva, it is related most closely to Heligmosomum and Heligmostrongylus. On the basis of the double dorsal rays of the male bursa it is closest Heligmostrongylus. It differs from this genus in lacking the dorsal wing, in having the cephalic dilation of the cuticula in the form of two wings with transverse striations, and in lacking a ventral process of the cuticula to cover the vulva. Because of these differences, I propose this new species as the type of a new genus:

Nematospira Gen. Nov.

Heligmosominae: Body red and spirally coiled. Head small, with three lips. Cuticula around head and inflated to form two wing-like swellings, limited posteriorly by a ring-like constriction and showing transverse striations. Rest of body covered by faint transverse stria-

tions and numerous distinct longitudinal ridges separated by similar fine striations. Cervical papillae absent or minute. Prebursal papillae absent. Bursa indistinctly trilobate. Dorsal rays double, small, and attached to bases of externo-dorsals. Lateral rays with a common base. Ventro-lateral and ventro-ventral rays with a common base. Spicules long, slender, usually twisted; grooved on the ventral surface. Gubernaculum present. Vulva just anterior to anus. Ovejector well developed and muscular. Eggs small, oval, rugose and thin-shelled. Parasitic in the digestive tract of rodents.

Type-species: *Nematospira turgida.*

The following key for the Heligmosominae is based upon those issued by Hall and by Cameron but modified to include the new genus described above.

TRICHOSTRONGYLIDAE LEIPER

A. Trichostrongylinae Leiper (Double genital apparatus in the female).
B. Heligmosominae Travassos (Single genital apparatus in the female)....1
1. Body rolled in a permanant spiral....................................2
   Body not rolled in a permanant spiral................................5
2. Vulva in anterior half of body..................Heligmosomoides Hall
   Vulva in posterior half of body......................................3
3. Longitudinal body striations prominent; over 25.....Nematospira Walton
   Longitudinal body striations not prominent; under 25..................4
4. Ventral rays as well as M.L. and P.L. united in basal two-thirds. Viannella Travassos.
   Ventral rays as well as M.L. and P.L. not united in basal two thirds. Viannaia Trav.
5. Dorsal ray single....................Heligmosomum Railliet and Henry
   Dorsal ray double........................Heligmostrongylus Travassos

Contracaecum quadricuspe sp. nov.

The material of this species was collected from the proventriculus of a Little Green Heron caught near Monticello, Illinois, in the spring of 1923. The body is cylindrical, tapering slightly at each extremity, and with the tail ending abruptly as a terminal spine. The color of the living worm is pale yellow due to the pigment in the intestinal walls. The cuticula shows transverse striations which are 6 to 8μ apart in the mid-body region. A very fine criss-cross of oblique striations is barely discernible under high magnifications. Just posterior to the head region the striations are deeper and are somewhat telescoped one within the other, making a distinct shoulder above which rises the head. The mouth is surrounded by three labia and three interlabia (Fig. 13). The head is about twice as broad as long and is three-fifths the width of the body behind the shoulder (Fig. 15). The cuticula over the lips is thick and shows radial striations. The labia are provided with two lateral and two median cusps. The lateral cusps are very distinct and longer than broad. The median cusps are low and broader than long.

The inner margin of these median cusps is provided with sharp cutting plates or ridges of cuticula. There are four double papillae present, two on the dorsal lip and one on each of the two latero-ventral lips. The interlabia show a shelf-like ridge on their inner surface, shortly above their base. A single tooth-like projection is found on the outer surface, just behind the tip of each interlabium. No cervical alae are present, but a pair of distinct laterally placed cervical papillae are found 490 to 590μ behind the tip of the head. The esophagus consists of two portions, a long anterior muscular portion which tapers toward the mouth, and a short, glandular, ventricular bulb. Extending posteriorly from the bulb is an esophageal glandular cecum, the capillary tubes of which empty into the ventriculus opposite the intestinal opening (Fig. 20). This gland is therefore drained by two minute capillary tubes as are those of *C. osculatum* and *C. spiculigerum*. The dorsal digestive gland opens into the esophagus at about the level of the nerve ring. An intestinal cecum is present, extending as a gradually tapering pouch along the dorsal side of the posterior four-fifths of the esophagus. The intestine proper extends from the region of the ventriculus posteriorly to the rectum. The inner surface of the walls of the intestine are thrown into distinct folds, increasing the absorbing surface greatly. The nerve ring surrounds the esophagus about halfway between the head and the tip of the intestinal cecum. The excretory gland is unpaired and lies along the left lateral line, extending from the region of the nerve ring back to the region of the rectum, the length of the intestinal organ, and giving off an anterior duct which opens to the exterior at the base of the ventral interlabium.

Male.—Body length 27.5 mm.; body width, head 240μ, ventricular region 640μ, mid-body 770μ, anal region 190μ. The caudal extremity is conical and strongly hooked ventrad; no lateral alae present; the anus opens 220 to 230μ from the tip of the tail. The ventral surface of the tail bears twenty- three pairs of papillae arranged in three groups (Fig. 17): one group of four papillae in each of two rows extending across the tail just in front of the terminal prolongation; one group of two large papillae immediately behind the anus, of which the more anterior is slightly nearer the median line though several irregularly placed minute papillae are between groups one and two; and a third group consisting of two slightly divergent rows of sixteen or seventeen graduated papillae each, beginning at the level of the anus with the largest and passing anteriad and slightly dorsad until the smallest one is approximately opposite the level of the base of the spicules and over the lateral line of the body. The spicules are equal, provided with a central canal-like structure and two lateral wings, and measure 2.9 mm. in length and 24μ in width. They are typically fully retracted. The

accessory piece measures 100 by 160μ and is very thin. The posterior 2.5 mm. of the ejaculatory duct passes through a large and well developed cement gland. The esophagus is made up of two parts, the muscular portion being 3.2 mm. in length and tapering from 160 to 112μ, while the ventriculus is 175 by 175μ. The esophageal cecum is 80 by 800μ. The intestinal cecum is 2.8 mm. in length and tapers from 260 to 80μ. The intestine averages 400μ in width and is 21.8 mm. in length, opening through a cuticula-lined rectum 320μ long to the anus, which is 225μ from the posterior end. The nerve ring is 500μ from the tip of the head. The cervical papillae are approximately at the level of the nerve ring.

Female.—Body length 37.9 mm.; body width, head 320μ, ventricular region 736μ, vulva 1.02 mm., mid-body 1.07 mm., anus 320μ. The posterior end is sharply conical, with the anus opening 400μ from the tip, and two lateral papillae 96 to 100μ in front of the caudal projection. The vulva is located 9.6 mm. from the head, at about one-fourth of the body length. It opens into the vestibule of the ovejector which extends posteriorly for 3.6 mm., followed by a thin-walled, coiled uterus of 1.2 mm. in length, before giving off the anteriorly and posteriorly directed uteri. The eggs are variable in shape, ranging from spherical to ovoid; the average size being 40 by 60μ. They possess a rough outer shell and are in the morula stage at the time of laying. The muscular esophagus is 3.56 mm. in length and tapers from 160 to 120μ in width. The ventriculus is 175μ in diameter, giving off a ventro-caudal cecum 80 by 816μ. The intestinal cecum tapers from 400 to 100μ in width and extends forward 2.9 mm. The nerve ring surrounds the esophagus about 600μ from the mouth and at practically the same level the two lateral cervical papillae arise. The intestine proper averages 640μ in width and is 33.28 mm. in length, opening into a rectum 480μ long.

The Herons, as water inhabiting birds, have long been recognized as hosts to Nematodes which now are placed in the genus Contracaecum. Rudolphi described *C. spiculigerum* (Syn:—*Kathleena arcuata* Gedoelst) from Ardea species, *C. rosarium* from Nycticorax as described by Connal, *C. tricuspe* and *C. punctata* by Gedoelst from African Herons and Ibises, and *C. multipapillatum* from a South American Ibis by von Drasche. The present form from the Little Green Heron is like these forms in the general generic characters, but differs in body color, shape and arrangement of mouth parts, and other essential structures of sufficient value to justify its establishment as a separate species. Because of this dissimilarity, not only to other forms found in related hosts, but also to the other known species of Contracaecum, I propose the following name for the above described form, based upon the peculiar form of the labia:

Contracaecum quadricuspe sp. nov.

Habitat:—*Buforides virescens virescens* (Linn.)—Little Green Heron. Free in proventriculus. Type specimens in the Parasitological Collection of the Department of Zoology, University of Illinois.

The next two species were collected from the Northern Flicker, several specimens of which were caught near Monticello, Illinois, during the spring of 1923.

Capillaria longistriata sp. nov.

While alive the parasites are white in color, somewhat twisted in position and are found free, mixed with mucus contents of the intestines. The worms are extremely slender, the males average 20 mm. in length and 0.04 to 0.05 mm. in diameter, while the females average 19 mm. in length and 0.06 to 0.07 mm. in diameter. The esophageal regions of both sexes are more attenuated than the rest of the body, which reaches its maximum diameter about three-fourths of the length from the head, decreasing very slightly in the last quarter. The cuticula is faintly striated longitudinally, an extremely minute transverse striation being practically masked.

The cephalic end is smoothly rounded and about 5 to 6μ in diameter in both sexes (Fig. 1). The lips are very poorly developed. No buccal capsule is present, the mouth cavity opening directly into the minute esophagus. This organ is slightly sinuous, very slender and thin-walled, increasing gradually in diameter from 2 to 11μ as it passes caudad. It is 7 mm. long in each sex. The esophagus is eccentric in position, being partially embedded in giant glandular cells for the greater portion of its length (Figs. 6, 7). This glandular material is divided into two regions; the anterior two-thirds is a syncitial mass with large scattered nuclei, gradually giving rise to definite bead cells which occupy the last third of the distance. These cells are large (10 by 30μ) with a large nucleus, and in the living condition are capable of slow rhythmic contractions and showing strong molecular motion in the cytoplasm of certain of them. When fixed and stained, the contracted cells show a more granular cytoplasm than do the expanded ones, probably due to the loss of the secreted fluid which thus leaves the permanent cell contents more compactly placed. The thin walled intestine passes caudad to the rectum, which is muscular at its anterior end and is lined with cuticula where it joins the cloaca. In the male the intestine is about 14 mm. in length and 35 to 42μ in diameter, in the female it is about 12.5 mm. in length and 50μ in diameter. The cloaca of the male is about 25μ in diameter while that of the female is tubular and 40 to 50μ in length. The anus in both sexes is sub-terminal, lying as a transverse oval slit about 10 to 15μ in front of, and ventral to the tip of the tail. The nerve ring is very small and is found approximately

0.16 to 0.18 mm. from the head. Lateral bacillary bands are present, becoming visible at the level of the nerve ring. No trace of excretory pores or canals were found. Cephalic, cervical and pre-bursal papillae are apparently absent.

The testis is a single, slightly convoluted tubule which begins slightly posteriad and passes anteriad to the level of the esophageal valve before emptying into the vas deferens. This structure passes caudad as a highly convoluted tube, opening into a thin-walled, highly distensible seminal vesicle. This latter opens into the narrow, muscular-walled ejaculatory duct which carries the spermatozoa to the cloaca. The ovary is likewise unpaired; beginning in the last fourth of the body, it stretches caudad, giving rise to the slightly convoluted oviduct which then turns cephalad, and after forming a small seminal receptacle, opens into a highly muscular ovejector (Fig. 9). The oviduct is approximately 5 mm. in length and 0.045 mm. in diameter. The ovejector is approximately 200μ in length and 25μ in diameter. This opens into the long vagina which is lined with cuticula at its outer end. The vagina is about 1 mm. in length and 0.03 mm. in diameter. The vulva (Fig. 10) is a transverse slit with lips which are flush with the surface of the body, and is located between 7.5 and 8 mm. behind the head, slightly posterior to the junction of the esophagus and the intestine.

The tail of the male is flattened out into two small wings which are bent ventrad and are surrounded by slight dilations of the cuticula. The posterior tip of each wing shows a large hook-like papilla which is bent ventro-cephalad. There is a median terminal papilla, as well as a single pair of ventro-lateral papillae which are slightly pre-anal in position (Figs. 11, 12). The single spicule is long, stout, and rather obtusely pointed. It is approximately 1.5 mm. in length and 0.1 mm. in diameter. It shows two strong ventral ridges, making the ventral surface seem somewhat hollowed out in consequence. The spicule is incased in a sheath which is superficially covered by definite transverse markings, but which lacks any spines. The sheath and spicule are typically retracted, the external opening being distended by a bow-shaped structure of cuticula—possibly the *telamen* of Hall. No accessory piece is present. The tail of the female is digitiform and stout, extending 10 to 15μ back of the anus and lacking papillae. The eggs are oval and possess the two terminal plugs characteristic of the family. The shell is thick and the outer coat is marked with short lines which gives it the appearance of being longitudinally striated. The embryo is just being delineated at the time that the eggs are deposited in long, mucous covered strings which contain ten to twenty eggs each. The eggs measure 15 by 45μ.

Habitat:—Small intestine of the Northern Flicker, *Colaptes auratus luteus* Bangs. Monticello, Illinois.

The Woodpeckers have been known to be hosts of members of the Trichiuridae since Rudolphi described a form, *Trichosoma picorum,* from European species. Leidy (1856) described a form from a Mexican Flicker which he called *Trichosoma picorum* and which Stossich (1890) believed to be identical with Rudolphi's species. Later workers have doubted this identity because of the differences in the description of the two forms and the different hosts. Travassos (1915), in his paper on the genus Capillaria, transferred Trichosoma to Capillaria and called the form described by Rudolphi, *Capillaria picorum* (Rud.) Travassos. As he did not regard the two forms of *T. picorum* as identical species, therefore the name *picorum* was preempted by Rudolphi and the species of Leidy's must be renamed. Travassos then suggested the name leidyella, thus making the species *Capillaria leidyella* Trav. In the case of both of these forms the descriptions are so scanty as to make identifications extremely difficult. The writer has made studies of others of this same genus and has found variations within undoubted species which are greater than those differentiating the two above mentioned forms and for that reason is of the opinion that all of the material described by Rudolphi and by Leidy should be referred to the one species, *Capillaria picorum* (Rud.) Trav.

The form described in this paper differs from *C. picorum* as well as from the other members of the same genus, not only in measurements, but in such fundamental characteristics as the structure of the esophageal sheath, the presence of bursal wings in the male, the position of the anus and the proportion between the esophageal and intestinal regions of the body. Because of these differences worthy of specific rank, the following name is suggested for the material described above:

Capillaria longistriata sp. nov.

Habitat:—Small intestines of *Colaptes auratus luteus* Bangs. Monticello, Illinois. Type material in the Parasitological Collections of the Zoology Department, University of Illinois.

Habronema colaptes sp. nov.

Examples of this nematode were found in the proventriculus of the Northern Flicker. When living, the worms are yellowish-white in color, slightly coiled, and embedded in the mucus covering of the inner surface of the proventriculus. The body is of medium thickness in both sexes, tapering slightly toward each end and showing the characteristic narrow lateral wing-like ridges of the genus. The females are 15 to 30 mm. in length and 0.4 mm. in maximum diameter. The

males are 10 to 15 mm. long and 0.3 mm. in maximum diameter. The male bursa is long and narrow, slightly wider than the greatest diameter of the body. The cuticula is striated transversely except for the ventral side of the bursa, which is covered by longitudinally arranged rows of scale-like cuticular flaps.

The head (Figs. 16, 18, 19) is provided with two large lips and partially covered by a prepuce. It is practically circular in outline, the diameter being approximately 0.25 to 0.30. The mouth is surrounded by two large lips, each of which is further sub-divided. Externally are three larger and two smaller divisions with heavily cuticularized margins. The three larger portions are each provided with a small papilla. Immediately within this circle of labia are two rows of three papillae each, tipped by denticles and placed one row to either side of the mouth opening. This opening is supported by a cuticular ridge and leads into a buccal capsule lined with a thick, cuticular membrane. From the buccal capsule the trifid esophagus passes caudad to the intestine. The esophagus is straight and slender, tapering gradually from its posterior end. Shortly behind the nerve ring, the esophagus changes from a short anterior, purely muscular portion to a long posterior, highly glandular portion. The ratio between the two parts is usually one to six or seven. The esophagus opens into the intestine by a large three-parted, nipple-like valve which pushes out into the lumen of the intestine about 0.1 mm. The intestine in both sexes shows a very decided anterior loop, passing forward 0.3 to 0.4 mm. The rectum of the female is short and narrow, lined by cuticula, and opening into an anus on a level with the surface of the body (Fig. 23). The nerve ring surrounds the esophagus just anterior to the division between the glandular and muscular portions, and in advance of the excretory pore which passes obliquely through the cuticula, running caudad from the surface. It opens in the mid-ventral line 0.4 to 0.5 mm. from the head end of the male and 0.5 to 0.6 mm. from that of the female. The cervical papillae are absent or extremely minute and difficult to identify.

The testis is a long, slightly coiled tube which rises in the posterior end of the worm and passes forward, opening into a seminal vesicle and a vas deferens. This tube passes cephalad to the upper end of the intestine before turning caudad to open into the cloaca. The ovaries are paired, as are the uteri, and open in a short, claviform, common ovejector. The vagina is short and surrounded by several unicellular glands. The vulva is transverse and is not raised above the level of the body surface. It is placed anterior to the mid-region of the body. The male bursa (Fig. 25), is very similar to that of a Physalopteran in that the edges are fused along their entire length and are marked by cuticular processes in characteristic manner and supported by papillae, both

stalked and sessile. There are four pairs of pre-anal and two pairs of post-anal stalked papillae. There is a single sessile papilla, occasionally paired, just in front and to the left of the anus. There are two groups of extreme ventral caudad sessile papillae with five members in each group. The asymmetrical position of the right hand member of the first pair of post-anal papillae is characteristic of the genus as is also the single pre-anal median papilla. The spicules are unequal and unlike, the shorter being stout and twisted one-half turn. The longer one is slim and straight. An accessory piece is present, often very irregular in outline (Fig. 21). The tail of the female (Fig. 23) is obtuse, with a small terminal projection as in the male. Several terminal cement glands and a pair of ventro-lateral pores are present. The eggs, which are 25 to 30μ by 35 to 40μ, are oval, thin-shelled, and are in the morula stage when deposited.

This new species is similar in many ways to *Habronema mansioni* Seurat and to *Spiroptera longistriata* Molin, reclassified by Seurat as *Habronema longistriata,* both recorded from woodpeckers, but differs from them in that it possesses a definite anterior loop in the intestine, a nipple-like esophageal valve, slightly different arrangement of the mouth parts, different number of ventral caudal papillae and much greater disparity in the sizes of the two spicules. Because of these differences I regard the form as new.

Habitat:—Proventriculas of *Colaptes auratus luteus* Bangs. Monticello, Illinois. Type material in the Parasitological Collection of the Zoology Department, University of Illinois.

Including the above described new genus and the four new species, examination of thirty different parasitic worms indicated records of new hosts for some and new place records for others.

NEW HOST RECORDS

Name	Former Hosts	New Hosts	Locality
Acuaria spiralis	Chicken	Bronzed Grackle	Urbana, Ill.
Capillaria longistriata	....	Northern Flicker	Monticello, Ill.
Contracaecum quadricuspe	....	Little Green Heron	Monticello, Ill.
Cruzia tentaculata	Various Marsupials	N. A. Opossum	Urbana, Ill.
Habronema colaptes	....	Northern Flicker	Monticello, Ill.
Nematospira turgida	....	Field Mouse	Urbana, Ill.
Syphacia obvelata	Various Rodents	White Rat	Urbana, Ill.

AMERICAN RECORDS FOR THE FOLLOWING SPECIES

Name	Former Record	American Record
Acuria spiralis	Europe, Africa	Urbana, Ill.
Cruzia tentaculata	Europe, Africa, South America	Urbana, Ill.

NEW LOCALITY RECORDS WERE OBTAINED FOR THE FOLLOWING AMERICAN SPECIES

Name	Former Record	New Record
Heterakis papillosa	Cosmopolitan	Urbana, Ill.
Physaloptera turgida	Eastern U. S. (Leidy, etc.)	Urbana, Ill.
Syphacia obvelata	Cosmopolitan	Urbana, Ill.
Trichosomoides crassicauda	Cosmopolitan	Urbana, Ill.

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Explanation of Plate VI

Fig. 1.—*Capillaria longistriata.* Anterior end of female, showing nerve ring and beginning of glandular sheath of esophagus. × 285.

Fig. 2.—*Nematospira turgida.* Dorsal view of anterior end of female. × 115.

Fig. 3.—*Nematospira turgida.* Face view of anterior end of male. × 115.

Fig. 4.—*Nematospira turgida.* Habit sketch of male. × 20.

Fig. 5.—*Nematospira turgida.* Lateral view of anterior end of female. × 115.

Fig. 6.—*Capillaria longistriata.* Esophageal region of female, showing syncitial nature of glandular sheath. × 285.

Fig. 7.—*Capillaria longistriata.* Transition of syncitium to bead cells in esophageal sheath. Female. × 285.

Fig. 8.—*Nematospira turgida.* Cross-section, mid region of female. i. = intestine. × 250.

Fig. 9.—*Capillaria longistriata.* Ovijector region, showing connection to oviduct and vagina. × 285.

Fig. 10.—*Capillaria longistriata.* Vulva region, showing transition of esophagus into intestine. × 285.

Fig. 11.—*Capillaria longistriata.* Posterior end of male, ventral view. × 285.

Fig. 12.—*Capillaria longistriata.* Posterior end of male, lateral view. × 285.

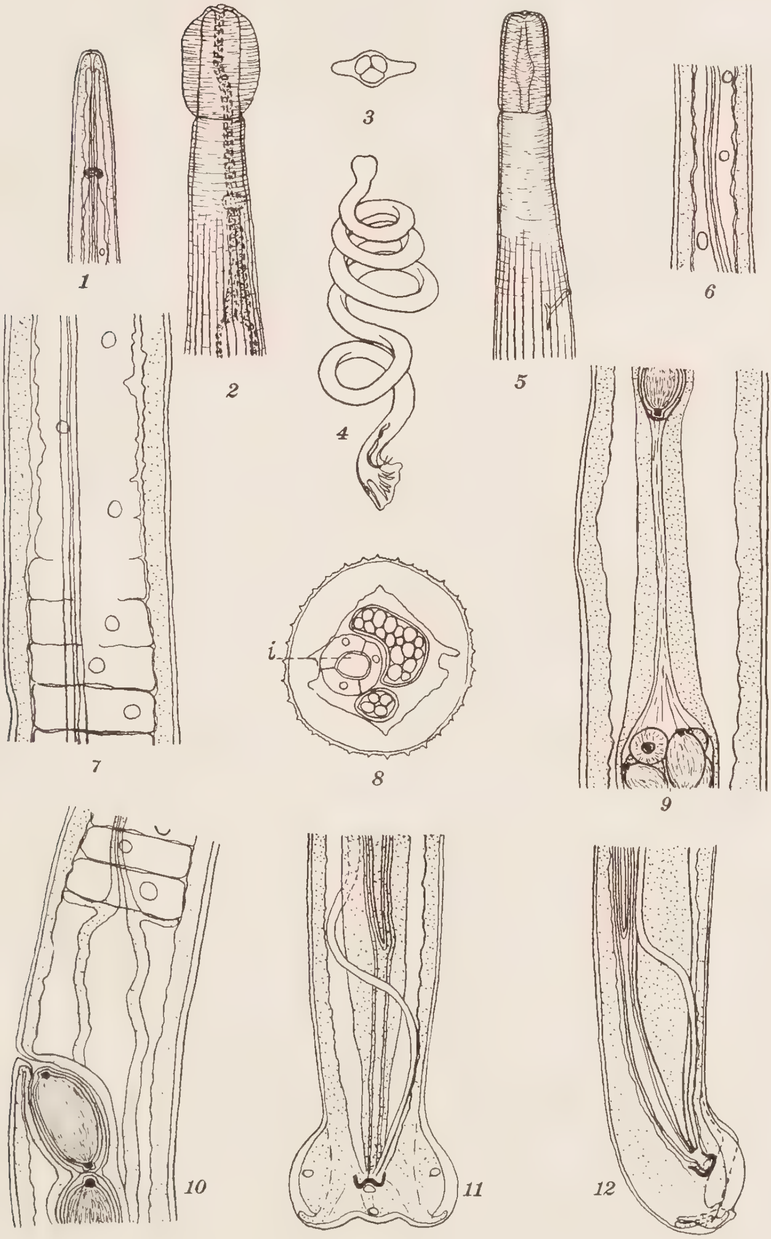

PLATE VI

Explanation of Plate VII

Fig. 13.—*Contracaecum quadricuspe.* Face view of head of male. × 100.

Fig. 14.—*Nematospira turgida.* Habit sketch of female. × 17.

Fig. 15.—*Contracaecum quadricuspe.* Dorsal view of head of male. × 100.

Fig. 16.—*Habronema colaptes.* Head of male, dorsal view. × 115.

Fig. 17.—*Contracaecum quadricuspe.* Ventral view of tail of male. × 100.

Fig. 18.—*Habronema colaptes.* Head of male, lateral view. × 115.

Fig. 19.—*Habronema colaptes.* Head of male, face view. × 85.

Fig. 20.—*Contracaecum quadricuspe.* Diagram showing the relationship of the esophageal, intestinal and cecal openings to the cavity of the ventricular bulb. × 100.

Fig. 21.—*Habronema colaptes.* Spicules and gubernaculum, ventral view. Right spicule, 440μ. Left spicule, 2 mm. Gubernaaculum, 140μ. × 200.

Fig. 22.—*Nematospira turgida.* Posterior end of male. × 85.

Fig. 23.—*Habronema colaptes.* Tail of female. Semidiagrammatic. × 115.

Fig. 24.—*Nematospira turgida.* Posterior end of male. × 85.

Fig. 25.—*Habronema colaptes.* Tail of male. × 115.

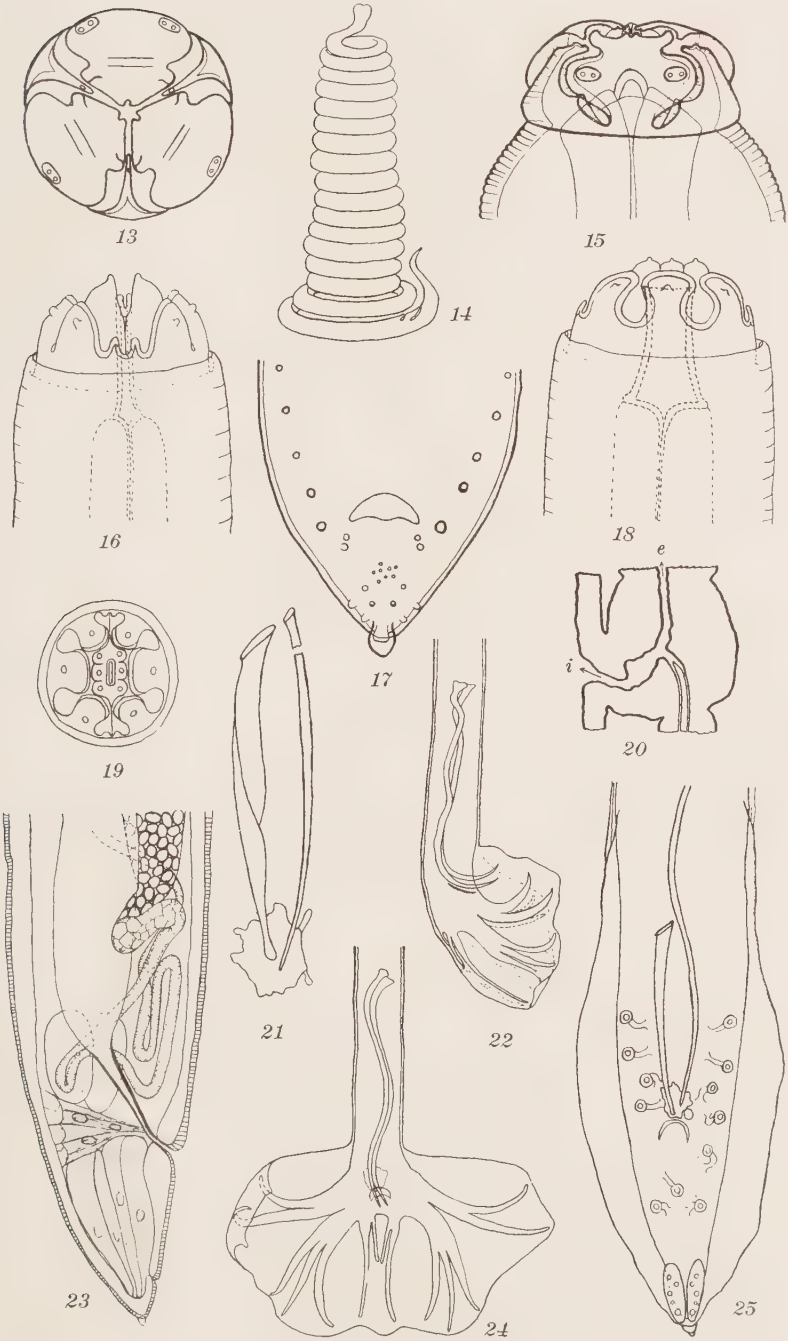

PLATE VII

ON THE STRUCTURE, OCCURRENCE AND SIGNIFICANCE OF *ATHESMIA FOXI*, A LIVER FLUKE OF AMERICAN MONKEYS *

Horace W. Stunkard

While making parasitological examinations of animals that had died in Bronx Park, New York City, I discovered several trematodes in the liver of a sapajou monkey, *Cebus apella.* In a preliminary report of these worms (Stunkard, 1923) the name *Hepatotrema cebi* was proposed for them. They agree most closely with the generic diagnosis of Athesmia, but differences in the relative width of the body, position and extent of ceca, size and relation of cirrus sac, and in the character and location of the uterine coils seemed at first to preclude the possibility of including these specimens in that genus. Examination of the type material of *Athesmia foxi* however, discloses considerable variation from the description. The uterine coils may either lie in the area between the ceca or extend lateral to them, and other features regarded as distinctive are subject to such variation that they can hardly be used for specific diagnosis. With the consequent changes that must be made in the generic description of Athesmia, the worms I have collected may be ascribed to that genus. Certain of these specimens manifest marked similarity to specimens of *Athesmia foxi,* and although there are points of difference and wide variations, I find no constant characters that separate them and the specimens of *A. foxi* into distinctly different groups. Consequently, I shall revise the specific diagnosis of that form to include them, and the name *Hepatotrema cebi* disappears as a synonym.

The genus Athesmia was created by Looss (1899) to contain a species described by Braun (1899) as *Distomum heterolecithodes* from the hepatic ducts of *Porphyrio porphyrio.* Four specimens were found in the liver of this bird which had been brought from Madagascar and died in the zoological garden at Königsberg, Germany. On the basis of eleven specimens found in a second bird, Jacoby (1899) made additions to the original description. In a second paper (1899*a*) he reported the discovery of five specimens in the liver of *Gallinula chloropus* from East Prussia, showing that the form was a parasite in that portion of Germany. Later (1900) he gave a more extended description and figures of the worms. Subsequently this species has been encountered but once, in the Swedish Zoological Expedition to

* Contribution from the Biological Laboratory, New York University.

Egypt and the White Nile. Describing this material, Odhner (1910) reported one specimen from the hepatic ducts of *Himantopus candidus* and two specimens from the hepatic ducts of *Parra africana.*

A new species, *Athesmia foxi,* was described by Goldberger and Crane (1911) from the liver of *Cebus capucinus,* a South American monkey that was accidentally killed in the Hygienic Laboratory at Washington, D. C. These authors gave the generic diagnosis of Athesmia as stated by Looss, a specific diagnosis of *A. heterolecithodes* compiled from the descriptions of Braun and Jacoby, and an extended generic diagnosis based on the two species *A. heterolecithodes* and *A. foxi.* The parasites from the monkey were carefully described and their position as a new species clearly demonstrated. A third species, *Athesmia atillae,* was briefly described by Travassos (1917) from the biliary ducts of *Attila cinerea,* a South American bird. The form resembles *A. heterolecithodes* rather closely, but is only about one half as large.

Since the specimens found in the liver of *Cebus apella* manifest considerable variation from the description of *A. foxi* based on material from *C. capucinus,* a description of these worms is essential as a basis of comparison, and also to give a more complete knowledge of the form. Twenty-six specimens were removed from the hepatic and interlobular bile ducts, and since the common bile duct, cystic duct and gall bladder were not parasitized, the biliary ducts appear to be the habitual seat of infestation. Although they must have occasioned considerable occlusion of the hepatic ducts, the movement of the worms would probably prevent chronic retention of the bile and there was no marked cirrhosis of the liver. The worms were difficult to dislodge from the liver tissue, but when freed from the biliary ducts they manifested only slight movements. The body was extended and contracted, especially the anterior portion, and when applied to the glass dish in which the dissection was made, the suckers did not adhere firmly but were moved about as though the fluke were seeking a different surface for attachment.

The parasites (Fig. 1) are elongated, flattened worms with almost parallel sides. The lateral edges are thin and frequently present a sinuous appearance. The anterior end is rounded, conforming to the shape of the oral sucker, and the posterior end is sharply pointed. The body is conspicuously narrower in front of the genital pore, and this anterior portion is only slightly wider than the oral sucker. The posterior half of the body is distended with uterine coils and is usually the region of greatest width. The specimens do not vary greatly in size. They measure from 7 to 10 mm. in length, from 0.5 to 0.75 mm. in width and from 0.17 to 0.43 mm. in thickness. The worms are relatively thin, and due to the weak and scanty muscles of the body wall,

they are very transparent. The acetabulum is situated about one eighth of the body length from the anterior end. It is almost spherical, and measures from 0.2 to 0.23 mm. in length and from 0.18 to 0.21 mm. in width.

The cuticula measures from 2 to 3μ in thickness and lacks spines or other modifications. The dermomuscular sac is slight and delicate, although the usual circular, longitudinal and oblique fibrils may be distinguished. The parenchyma is loose and vacuolated with strands of branched mesenchymal fibers traversing the body dorsoventrally. Throughout the body the cytoplasm of the parenchyma cells contains a yellow or brown refractive substance which resembles the vitelline material. Usually it is in the form of small droplets, although sometimes accumulated in masses.

The mouth opening is subterminal. The oral sucker is spherical to oval, usually slightly longer than broad, and measures from 0.24 to 0.29 mm. in length and from 0.23 to 0.26 mm. in width. It is followed immediately by the pharynx, a spherical organ, 0.08 to 0.1 mm. in diameter. The esophagus is nearly uniform in width, varying from 18 to 28 microns in diameter; has a cuticular lining, and is surrounded by a layer of cells whose nuclei stain heavily. The alimentary tract bifurcates midway between the suckers; the intestinal ceca diverge at an angle, extend caudally in nearly straight lines, and end blindly about two sevenths of the body length from the posterior end. These tubes are almost uniform in size throughout their extent, and measure from 20 to 40 microns in diameter. Usually one of the ceca extends farther posteriad than the other. Either cecum may be the longer. In one specimen the cecum of the vitelline side ends 0.74 mm. anterior to the caudal margin of the vitellaria, whereas the cecum of the opposite side extends 0.12 mm. behind the vitellaria. In another specimen the cecum of the vitelline side extends 0.54 mm. posterior to the vitellaria, whereas the cecum of the opposite side ends 0.63 mm. anterior to the caudal margin of the vitellaria. In a third specimen both ceca extend posterior to the vitellaria, that of the vitelline side 0.24 mm. and that of the opposite side 0.15 mm.

The excretory system is distinctive and the position of the principal ducts is clearly marked. I have not studied the system in living specimens, and only occasionally can the flame cells and their capillaries be distinguished in sections. The excretory pore is terminal, and the excretory vesicle is large, extending forward on the dorsal side near the median plane to the center of the body. When the posterior end of the worm is contracted the vesicle assumes a zig-zag course, with five or six segments of approximately equal length. The vesicle bifurcates near the middle of the body and the collecting ducts pass forward on the dorsal side, median to the ceca. In the region of the cirrus sac they

pass underneath the ceca (Fig. 4) to a lateral position and continue forward. Near the level of the genital pore these ducts divide to form branches which pass forward on either side to the oral sucker and others that pass backward lateral and somewhat ventral to the ceca. The recurrent or descending tubules have been followed in sections farther caudad than the ends of the intestinal diverticula.

The reproductive organs present a characteristic appearance. The testes are lobed and are about the same size and shape; the cephalic testis about one fourth and the caudal testis about one third of the body length from the anterior end. In the majority of specimens the center of the anterior testis is slightly at the left of the median plane and the uterus passes forward on the right side of the testis. The uterus crosses the body between the testes and is situated on the opposite side of the caudal testis. Thus in the majority of specimens the uterus passes on the left of the caudal testis, and this organ is situated slightly at the right of the median plane. The testes measure from 0.43 to 0.6 mm. in length, 0.36 to 0.5 mm. in width, and from 0.26 to 0.36 mm. in thickness. The vas efferens from the caudal testis arises at the median anterior margin and passes forward on the dorsal side of the body. It is a very small tube, measuring from 6 to 10 microns in diameter. The vas efferens from the cephalic testis arises from the dorsal anterior face of the median lobe and joins the duct from the caudal testis. The vas deferens is 16 to 20 microns in diameter and passes forward on the dorsal side of the body. At the level of the acetabulum it bends ventrad and enters the posterior end of the cirrus sac. Within the sac it enlarges to form a coiled seminal vesicle (Figs. 4, 5), and frequently when the cirrus is retracted the ejaculatory duct is also coiled. The cirrus is large and prominent, measuring from 0.2 to 0.27 mm. in length and from 40 to 50 microns in diameter in the everted condition. The cirrus sac lies directly below the terminal part of the uterus and the two structures occupy practically all the space between the dorsal and ventral walls of the body at this level. It is a flask-shaped organ, the smaller end opens at the genital pore situated in the midventral line about half way between the suckers, and in a retracted condition it may extend posterior to the caudal margin of the acetabulum. There are a few cells with large nuclei between the wall of the sac and the ejaculatory duct. They appear to be secretory and undoubtedly represent a prostate gland, although the organ is not well developed.

The ovary is lateral in position, situated usually on the right side and slightly anterior to the middle of the body. It is spherical or oval in shape and conspicuously lobed. It may be longer in either the antero-posterior or lateral axis and varies from 0.27 to 0.37 mm. in length, 0.23 to 0.4 mm. in width, and from 0.12 to 0.18 mm. in thick-

ness. The oviduct arises from the ventral margin of the median posterior lobe and turns mediad and slightly dorsad. At this point (Fig. 3) it connects with the junction of the duct from the seminal receptacle and the base of Laurer's canal. A very short passage opens from the oviduct to a larger canal, often filled with spermatozoa, which runs transversely across the body. This canal extends a short distance on the ovarian side and opens into a large blind sac, the receptaculum seminis, which is usually filled with spermatozoa and stains deeply. The receptacle is circular from a dorsal aspect, measures from 0.09 to 0.11 mm. in diameter, is flattened dorsoventrally, and is located immediately behind the ovary. On the opposite side the transverse duct diminishes in size and becomes Laurer's canal. It passes laterad and cephalad, opening to the dorsal surface lateral to the uterine field. The oviduct continues dorsally, passing to the antovarian side of the body, where it turns caudad, enters the ootype region, and receives the vitelline duct. There is no vitelline receptacle. Mehlis' gland is large, the unicellular glands forming a conspicuous cluster about the ootype.

The vitelline gland consists of a more or less central stem with many lobed follicles. It is situated on the antovarian side of the body, and although occasional follicles extend mediad of the cecum, the mass of the gland lies lateral and ventral to the cecum of that side. The caudal limit of the vitellaria is about three tenths of the body length from the posterior end and anteriorly the gland extends to the posterior margin of Mehlis' gland, where a short vitelline duct leads to the ootype. No trace of double yolk ducts was observed, and from the position of the vitellaria it seems difficult to believe that the structure is formed by the fusion of two originally separate and laterally symmetrical beginnings. Consequently, I am inclined to believe that the vitelline gland of the ovarian side fails to develop and has been lost.

The course of the uterus manifests wide variation in different specimens, but always there is a descending limb passing posteriorly from the ootype almost to the end of the body, where it turns forward and continues as the ascending limb to the genital pore. Both uterine crura are much coiled and the loops are variable in number and position. The eggs near the ootype are colorless and almost spherical, but they grow longer and darker in color as they proceed through the uterine windings, so that the descending and ascending crura may be recognized in whole mounts. In Figure 1, I have indicated the descending limb in dotted lines and the ascending limb with unbroken lines. After emerging from the ootype the uterus winds caudad either on the vitelline or ovarian side. Near the level of the bifurcation of the excretory vesicle it frequently crosses to the opposite side. The descending limb is not restricted to either side, as there may be two, three or even four places where it crosses from one side of the body

to the other. At these points the ascending limb crosses to the opposite side of the body. The ascending limb passes forward on the vitelline side of the ovary and the caudal testis, crosses the body between the testes, and passes on the ovarian side of the cephalic testis. Anterior to the testicular zone, the uterus winds forward in the center of the body, passing on the dorsal side of the cirrus sac to open just in front of the cirrus (Fig. 5). The metraterm extends to the acetabular level but the muscles of the wall are not strongly developed.

In four of the specimens the ovary is situated on the left side of the body and there is a complete situs inversus of the other organs from the usual condition just described. In no case have I found the ovary and vitellaria on the same side.

The eggs have thick shells and are extremely numerous. Those in the initial portion of the uterus average 0.023 by 0.019 mm., whereas in the distal portion they average 0.027 by 0.019 mm.

The specimens just described are about the same size as the original material of *Athesmia foxi*. They are slightly longer and more slender than the type specimens but this can be explained on the ground that they were killed in a more extended condition. In most of my specimens the region of greatest width is in the posterior half of the body and not in the testicular region as described by Goldberger and Crane, but the region of greatest width is not constant and varies with the state of contraction. The lobes of the testes and ovary are usually fewer and more pronounced than in the original material but here also such variation exists that specific distinctions cannot be drawn. The course of the uterus is subject to unusual variation. In one of the two specimens figured by Goldberger and Crane the descending limb is on the vitelline side and the ascending limb on the ovarian side, in the other the descending limb crosses to the ovarian side and lies on that side for some distance. In my material the descending and ascending crura regularly cross from one side to the other, frequently three or four times. Braun observed in *Athesmia heterolecithodes* that the descending limb winds caudally in many coils on the vitelline side of the body with an occasional fold extending into the field of the opposite side. Jacoby reported great variation in the arrangement of the genital organs of that species. In twelve worms the descending limb of the uterus passes caudad on the vitelline side and in three specimens on the ovarian side of the body. The relative position of the crura, he stated, is not constant. Frequently one or more folds of either of the crura may extend into the field of the other, returning soon to the original side, or each may lie on one side of the body with a crossing over at the posterior end. The extensive variations and frequent amphytypie which occurs also in Opisthorchis and Dicrocoelium were discussed by Jacoby. In the

genus Telorchis I found (Stunkard, 1915) that the lateral extension of the uterus varies largely as a result of the congestion with eggs. In the same species, one finds some specimens in which the coils of the uterus are confined between the ceca and others in which the uterine folds overlap the diverticula on one or both sides. In this genus I found also individuals of a single species in which the descending and ascending uterine crura occupy separate fields on opposite sides of the body and others in which they cross each other to form a figure 8. In trematodes in which the uterus consists of numerous coils arranged in descending and ascending crura, the position of the coils is often subject to wide variation and this feature is in my opinion of slight taxonomic value. Consequently differences in the course of the uterine crura and arrangement of the coils need not be regarded as subversive of the specific identity of the material at hand and the specimens described by Goldberger and Crane. Measurements of acetabulum, oral sucker, pharynx, ovary, and testes in my material show divergencies in both directions from the figures given by Goldberger and Crane. In one place they state that the eggs measure 34 by 20 microns and in another 32 by 20 microns. On examination of their material, I find eggs as large as those reported but the average measurement of a large number of eggs is 27 by 19 microns, the same size as the eggs in my specimens.

With the inclusion of my specimens the specific diagnosis of *Athesmia foxi* should be revised as follows: Length 6 to 10 mm., width 0.5 to 0.85 mm.; region of greatest width either in the anterior or posterior half of the body. Cirrus sac may be preacetabular or extend caudad of the acetabulum. Ovary either sinistral or dextral, longer in either the longitudinal or transverse axis. Laurer's canal may arise at the junction of the oviduct and seminal receptacle and open in the zone of the ovary lateral to the uterine field. Vitellaria either dextral or sinistral. Uterus may be confined between the ceca or extend lateral to one or both diverticula; descending and ascending limbs may lie on either side of the body in separate fields or cross from one side to the other. Eggs average 27 by 19 microns. Excretory pore terminal; vesicle median, dorsal, extends to middle of body; collecting ducts pass forward dorsal and median to the ceca to the level of the cirrus sac where they pass laterad ventral to the ceca and continue forward to the level of the genital pore where each divides into anterior and posterior branches.

Athesmia foxi is similar to *A. heterolecithodes* in length, in the presence of an anterior conical region, in delicate musculature, in location, form, and relative position of the reproductive organs, and both are parasitic in the hepatic ducts. The two species however, manifest distinct differences. *A. foxi* is more slender, the suckers are much

smaller, the esophagus is shorter, the bifurcation of the alimentary tract is farther forward, the ceca are shorter, the cirrus sac is larger, and the eggs are smaller. This species is parasitic in American monkeys whereas *A. heterolecithodes* is parasitic in African and European birds.

The type species, *A. heterolecithodes* was first found in African birds that had been kept in a zoological park in Königsberg, Germany. The later discovery of the form in *Gallinula chloropus* from East Prussia suggests that the original parasites might have been acquired after the hosts were brought to the zoological park. Odhner's report of the species in material collected in Egypt and on the White Nile, however, confirms the suspicion that the type specimens came from Africa with their hosts and establishes that continent as a normal habitat of the parasite.

Further data concerning the original home of the infected monkeys and the time of their capture would be interesting. According to records at Bronx Park, the specimen of *Cebus apella* had been received some six months previously from British Guiana, South America. It is not improbable that the animal had been handed along by natives from hundreds of miles up one of the rivers and by this means came to the person from whom it was secured for the park. Since the monkey had been kept in captivity subsequent to its shipment from South America, the probability that the parasites were acquired after that time is extremely remote. It seems likely that the fluke is a South American form, and although the life history is unknown, it is not improbable that the worms gained access to the alimentary canal while the host was still in its native wilds. Considerable significance is attached to the discovery of this parasite in the liver of South American monkeys. It is entirely probable that it is a normal human parasite in its original location. Although the method of infestation is unknown, it appears probable that the parasites enter the alimentary tract of the host with food material. Since the materials utilized as food by these monkeys may often serve as food for the natives of the region, the likelihood of human infection is at once apparent. Once entrance is effected into the human digestive tract there is little doubt that the parasites would find there conditions favorable for development and continued existence. The well known similarity of common physiological processes in man and the anthropoid apes and the fact that both are subject to the same infections support this prognosis. Further support for the belief is afforded by the lack of specificity in the definitive host of the closely related form *Dicrocoelium dendriticum*. This species becomes sexually mature in many herbivorous and omnivorous mammals and has been removed from the biliary ducts of the sheep, goat, deer, ox, ass, horse, pig,

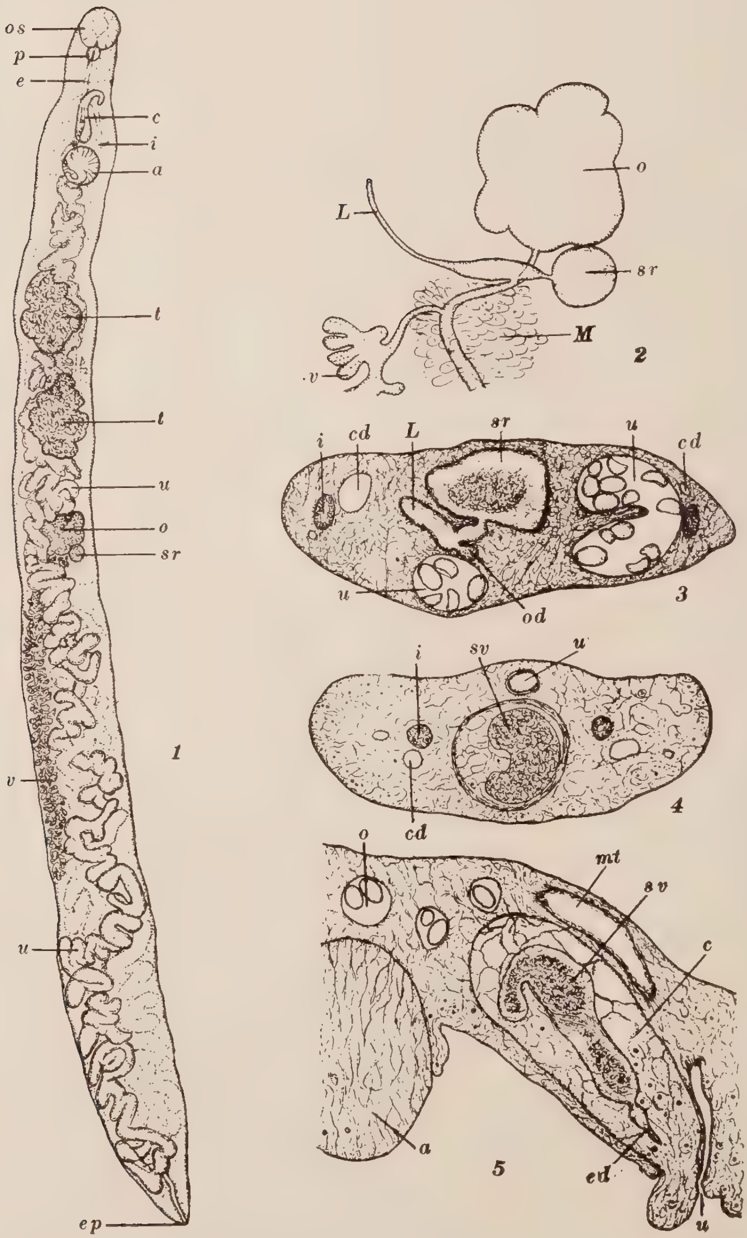
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PLATE VIII

rabbit, and cat. It is widely distributed over Europe, Asia, Africa, North and South America, and has been reported from man in France, Germany, Bohemia, Italy and Egypt.

SUMMARY

A second case of infestation by *Athesmia foxi* is recorded, naming a second species as host. Study of this material affords additional data on the anatomy of the parasite. Examination of the original material and comparison with the recently discovered specimens demonstrates extensive variation within the species and necessitates a revision of the specific diagnosis. The wide distribution of the genus and the significance of *A. foxi* as a probable human parasite are discussed.

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Explanation of Plate VIII

a, acetabulum	*o*, ovary
c, cirrus sac	*od*, oviduct
cd, collecting duct	*os*, oral sucker
e, esophagus	*p*, pharynx
ed, ejaculatory duct	*sr*, seminal receptacle
ep, excretory pore	*sv*, seminal vesicle
i, intestine	*t*, testis
L, Laurer's canal	*u*, uterus
M, Mehlis' gland	*v*, vitellaria
mt, metraterm	

Except Fig. 2 all are camera lucida tracings.

Fig. 1.—Whole mount, from *C. apella*, dorsal view. × 19.

Fig. 2.—Reconstruction of ootype region. × 65.

Fig. 3.—Cross section through the union of the oviduct, seminal receptacle and Laurer's canal. × 137.

Fig. 4.—Cross section a short distance anterior to the acetabulum, collecting ducts passing laterad below the ceca. × 137.

Fig. 5.—Sagittal section through the genital pore. × 137.

THE POISON AND POISON APPARATUS OF THE WHITE-MARKED TUSSOCK MOTH *HEMEROCAMPA LEUCOSTIGMA* SMITH AND ABBOT *

Paul M. Gilmer
Department of Entomology, University of Minnesota

It is ordinarily thought that poisonous Lepidoptera are relatively uncommon. As far as the imago is concerned this is true, in fact it is doubtful if the few imagoes that are credited with poisonous properties are strictly so, rather than owing the quality to poisonous larval hairs mechanically mingled with the hairs and scales of the adult. Among larval forms, however, poisonous properties are not so uncommon. A few families and a number of genera possess poisonous larvae, due to the presence of spines, prickles or hairs connected with venom glands. Rather prominent among these forms are the Liparidae, a number of the genera containing forms whose venomous properties are well established, while urticating effects from others have been reported. To this family belongs the rather notorious *Euproctis chrysorrhea,* or Brown-tail, and *Psilura monacha,* both of demonstrated venomous type. Another is the well known White-Marked Tussock moth, *Hemerocampa leucostigma,* which has ordinarily been considered innocent of poisonous effects.

That this idea is based upon incomplete knowledge of the insect is shown by references in literature to its irritating effects. Howard (1896) reported such effects from the larvae, attributing the poisonous element to "the shorter hairs from the sides" of the larvae. Göldi (1913) in his small booklet on disease producing insects also mentions it, although it is probable that the source of his information is this same note by Howard. Tyzzer (1907) in his work on the Brown-tail, assumed its innocence of venomous effects and used it as a check upon the Brown-tail poison, attributing the slight effect to mechanical irritation. Riley and Johannsen (1915) mention the reference of Göldi but class the species with those forms whose venomous properties were still in question. This was the state of the literature until Knight (1922) published a short note concerning the poisonous effects obtained from the cocoon hairs of this species. It was as a result of the preliminary experiments upon which this note was based that the writer undertook the investigation of the poison and its mechanism, the work forming a part of a broader study of the poisonous Lepidoptera being carried out under the direction of Dr. W. A. Riley.

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* Published with the approval of the Director as Paper No. 377 of the Journal Series of the Minnesota Agricultural Experiment Station.

The problem was attacked from both the chemical and morphological standpoint. Actual experiment showed that the urtication was not due to mechanical irritation. Mechanical injury by means of comminuted glass wool, designed to imitate the possible mechanical effects of the hairs, while it gave effects somewhat similar at first glance to the hair infections, never in any instance gave a swelling or itching comparable with that of the hairs. The magnitude of this glass wool irritation might be judged from the fact that the seat of entry of the glass particles was ordinarily marked by a slight hemorrhage as indicated by tiny blood dots beneath the skin. On the other hand, the extreme difference in degree of irritation, the great variation in the time of the appearance of the characteristic swelling and itching, a variation of from a few seconds to some three, four, or even as in one case ten days, showed rather conclusively that there existed some toxic agent. Some individuals showed complete resistance to it, most suffered comparatively little inconvenience, while a few suffered a very painful irritation, accompanied by an intolerable itching such as to interfere with sleep at night. The writer found himself in the intermediate position. The swelling occasioned was very considerable, but the pain and itching were rarely ever very great in degree. He has found, however, that just as Caffrey (1918) reports for individuals poisoned by the range caterpillar, *Hemileuca olivia,* susceptibility increases from year to year. Infections given this fall (one year after the original experiments) were of a character both more painful and much more persistent.

The chemical experiments were, on the whole, disappointing in result. Although practically all organic solvents were used, no solution of the active principle could be obtained. Nevertheless, a number of interesting facts were obtained. While the poison was insoluble, or at least very difficultly soluble in ordinary solvents, yet it showed rather characteristic properties. The presence of weak acids (0.2% hydrochloric) increased the degree of virulence markedly after a short immersion (3 to 5 hours). Bases in weak solution, as sodium hydroxide, potassium hydroxide, or ammonium hydroxide of 0.5% or less, as markedly decreased the urticating properties. Prolonged immersion in weak, or shorter immersion in stronger alkali caused a complete disappearance of the poisonous properties for some time, although when allowed to stand for some hours or days, the properties returned with apparently little if any loss. The same was found true of extreme heat. A temperature of 185°C. for an hour gave a temporary loss very similar to that obtained with alkalis. Moist heat was more effective than dry, steam heat at ten pounds pressure (about 105°C.) for fifteen minutes giving effects very comparable to dry heat at 185°C. Comparable penetration was obtained in both cases. The latter experiments show that the condition with heat is not due primarily to loss of moisture and

consequent dessication. The experiments also showed the loss to be a progressive one, delay in reaction time becoming gradually greater until temporary loss for some hours or days resulted.

Experiments with oxidizing agents showed the poisonous properties were closely associated with the remnants of dried protoplasm contained in the shed larval hairs. Complete oxidation of this protoplasm without affecting the structure of the hairs was obtained by the use of dilute potassium permanganate, and by the use of very dilute solutions of potassium bichromate and sulfuric acid. Loss of virulence was also progressive here, the loss being not a time of reaction factor but a degree of reaction one, and agreeing almost exactly with the degree of solution of the protoplasmic material. Complete solution was accompanied by complete loss of urticating power, without subsequent recovery, although the hairs were unaltered in structure and microscopic examination showed that penetration was taking place in the usual manner.

Investigation was made into the mode of entry of the hairs. It was found that the smaller barbed hairs were the agents producing the effect, neither the large black plume hairs nor the long barbed white hairs seeming to be concerned. The point of entry was invariably found to be the hair follicles, repeated efforts to infect the palms of the hands and the backs of the last joint of the fingers being unsuccessful. Effort to force the short hairs into the skin elsewhere than at the follicles resulted in the breaking of the hairs without effecting entry.

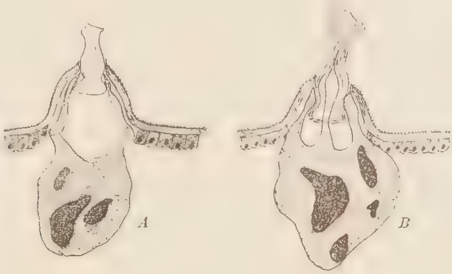
HISTOLOGICAL STUDIES

The preliminary chemical work was followed by a detailed histological study. For this purpose endeavor was made to rear from egg masses sufficient larvae for a complete series. At the same time advantage was taken of the rearing to find whether there was any difference in poisonous effect in the various instars. Larvae were hatched from eggs in the University insectary, and fed upon lettuce. For some reason, probably due to unnatural humidity conditions, it was found impossible to grow them beyond the fourth instar.

Examination of the larvae showed, however, that from the moment of hatching they were poisonous, becoming increasingly so with the development of the typical tussocks in the third and fourth instars. It was also found that the poisonous type of hairs were scattered over the body in company with the other hairs on the lateral and dorsal tubercles, particularly those of the first and last body segments. They were easily distinguished by being shorter and occurring in tufts of from six to a dozen hairs. Considerable difference was found between the various types of cells in connection with the body hairs. These might be divided into two general types; the true trichogen cells, secreting the chitin of

the hair and its follicle, and true gland cells, which communicate with the hairs through a small pore in the proximal end of the hair.

In connection with the large black plume hairs of the first and last body segments are to be found very large, peculiarly shaped cells; in the smaller larvae conspicuously the largest cells in the animal. From their peculiar shape they might be called trident cells due to their three-pronged appearance. The cell fits up closely about the heavy follicle or chitin ring in which the hair is set. This ring, or follicle, sets down somewhat below the level of the body chitin, much as a pipe might project within a barrel. The trident cell fits up closely about this ring, so that the structure has a ball-and-socket arrangement, the cell being the socket. A thin thread of protoplasm running from the center of the cell enters the hair through a proximal pore. These cells show the typical multinucleate appearance so characteristic of insect hypodermal glands, and at first were considered the probable poison gland cells.



Text figs. A, B. Trident Cells.

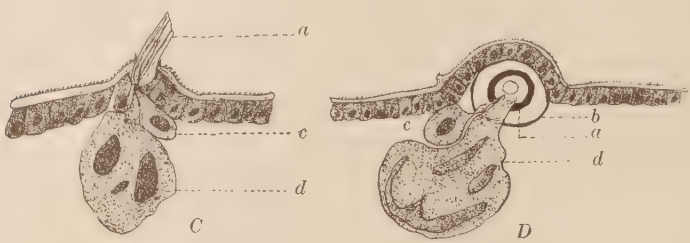
However, the fact of their connection solely with the non-toxic hairs disposed of this theory, for they are also found though somewhat smaller in size in connection with the long white hairs as well as with the black plume hairs. Their use is problematical. No other trichogen cell could be found in connection with these hairs in a very large number of preparations made, and it is possible they may serve merely as trichogens. Their immense size, and the rather typical glandular appearance, however, almost force the supposition that they are glandular in function.

In connection with the smaller hairs and trichogens may be found the typical trichogen cells, enlarged hypodermal cells, usually triangular in section, and generally crowded away from the hypodermis to such an extent as often to appear as a second hypodermal layer, especially where the hairs are close together. They communicate with the pore in the proximal end of the hair by a narrow neck and may be readily identified by the fact that they contain the usual large unbranched

nucleus. These cells are typical for the smaller types of hairs and are found in connection with the poison hairs.

THE POISON APPARATUS

The poison hairs are found scattered in small tufts all over the body. There are usually from six to a dozen hairs in each tuft, although occasionally they appear solitary. They are found on the lateral tubercles in rather few numbers, in fair quantity on the first thoracic segment, associated with the plume hairs in the dorsal tubercles, and rather more plentiful on the last abdominal segment in the similar dorsal plume tubercles. It was noted that when disturbed the larva had a habit of elevating the last few segments and wagging them back and forth, a habit possibly associated with the presence of these hairs and used as a means of protection. In all instars, except the first two, by far the greatest number of hairs were found in the dorsal white tufts on the first four abdominal segments which gives this species its name of



Text figs. C. Poison Apparatus. a. Poison hair; b. Follicle chitin ring; c. Trichogen Cell; d. Poison gland cell.
Text figs. D. Poison Apparatus (Looking into hair).

"tussock moth." Here the hairs occur in almost pure culture and in enormous numbers. They are characteristically short and loosely attached so that they drop out without difficulty. Each hair is attached to a trichogen cell and a gland cell, the latter crowding together below the hypodermis so closely as to give the appearance of a second or even a triple thickness of cells. Beside the neck of each such gland cell may be found the true trichogen cell, usually pushed down below the hypodermal layer and often times so crowded as to appear as a part of the gland, being forced into the gland cell itself. However, examination under high power in such cases readily shows the dividing line between the two cells.

Generally the gland cell communicates with the hair by means of a short, thick neck, abutting against the follicle chitin ring and completely filling it except for a thin fiber of trichogen cell protoplasm. However, where crowding is very great, as in the center of a tussock, the gland cells will be found in many cases communicating by means of a rather

elongated and slender neck. In such cases this thread of protoplasm may be seen entering the follicle ring in company with that from the trichogen cell. The gland cells are rather large cells, although much smaller than the enormous trident cells of the plume hairs. The nucleus usually appears single and very large, although in many cases there is a typical multinucleate appearance. This is due to sectioning a branching nucleus, a structure typical of insect hypodermal glands, but in these cells the branches must be short and stubby, rather than the thin connecting threads with enlarged ends as in the trident cells.

There is little or no variation in structure due to the age of the larva. The true poison hairs of the first instar were typically like those of the fourth, where they occur. The difference was a matter of quantity and distribution rather than of structure. The fact that in the first instar the glands seemed proportionally larger was due rather to the much smaller size of the larva as a whole than to an actual larger size in the gland cell itself. It will be noted that the condition here is different from that found by Kephart (1914) in the Brown-tail, where tufts of hairs were supplied each from a single large gland cell, with a small thread of protoplasm connecting hair and gland. Here, as is usual, each hair is armed separately, an independent unit.

The commonly held theory that the poison is secreted by the eversible dorsal glands on certain of the abdominal segments was first advanced by Goossens (1881) for the Pine Processionary, *Cnethocampa processionea*. According to him the hairs were smeared with a liquid from these red glands which upon drying envenomed them. Beille (1896) working upon the related *Cnethocampa pityocampa*, however, has shown a distinct poison apparatus connecting from hypodermal venom glands directly with the hairs themselves. Other work upon such forms has also shown similar hypodermal glands. The work of Kephart (1914) is an example. It is very evident that whatever the function of these eversible organs may be, at least they are not the source of venom in such forms as the Liparidae.

SUMMARY

1. The larva of the White-Marked Tussock moth, *Hemerocampa leucostigma*, is truly venomous; its virulence ordinarily is not great but varies with individual susceptibility, very few persons being totally immune.

2. This poisonous effect is due to the smaller white hairs, scattered over the body, chiefly on the lateral tubercles and on the dorsal plume tubercles of the first thoracic and last abdominal segments in the first two instars. They are particularly localized in the dorsal white tussocks on the first four abdominal segments in the later instars.

3. These hairs retain their virulence after being shed, both in the cocoons and in the shed larval skins.

4. The poison is particularly resistant to chemical agents, being insoluble in all ordinary solvents. The virulence is increased by acids, and decreased by alkalis of low concentration. It is resistant to both moist and dry heat.

5. The urticating material cannot be destroyed without dissolving out the protoplasmic content of the hairs.

6. The poison is a product of a special gland cell communicating directly with the hair, and independent of the trichogen or hair forming cell.

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Normal infection with hairs from the cocoon of the White Marked Tussock moth.

PLATE IX

Infection produced by poison hairs of the White Marked Tussock moth larvae, treated with 0.2% hydrochloric acid.

PLATE X

SPIRALED EXCRETORY TUBES IN *CYSTICERCUS FASCIOLARIS* *

THURLOW C. NELSON

A muskrat opened in our laboratory of animal parasitology contained in one lobe of the liver two yellow cysts of the well known larva of *Taenia taeniaeformis* (= *T. crassicollis*), *Cysticercus fasciolaris.* The larger of the cysts, 9.3 by 8.4 mm., yielded a cysticercus of 483 segments measuring when passively extended over 10 cm. in length (Fig. 1).

Johnson (1918), obtained from *Epimys norvegicus* a specimen of this cysticercus which was over 9.5 inches long, and in a single brown rat he found as high as 189 individuals, mostly of small size. This larval cestode has been reported from the muskrat by Stiles and Hassall (1894) and by Linton (1915). It is a form readily recognized by the large number of segments present, by the distinct terminal bladder, and by the very wide neck which is much broader than, and is not set off from, the head (Fig. 2).

The behavior of this cysticercus is of interest. Following the death of the muskrat the liver containing the cyst was left in salt solution for 30 hours, during which time the temperature was for the most part below 9° C. When freed from the cyst and placed in physiologic salt solution at room temperature the larva exhibited active movements, contracting and extending the body. The rostrum was at first fully extended, the rostellum was projected well forward, and the bothria were very prominent. After about 10 minutes the entire rostrum was drawn down into the neck and disappeared from view. Goeze, quoted by Leuckart, observed this cysticercus "stretching out its suckers like the horns of a snail." The same author noted also the great activity of the adult *Taenia taeniaeformis* when removed from the host.

The smaller of the two larvae is apparently normal but the larger one shows most unusual lateral excretory tubes. Each of these canals crosses over and passes down the opposite side of the worm for a number of segments, then re-crosses and crosses again, the two tubes forming in all eight chiasms. These points of crossing occur in the following segments beginning at the terminal bladder and counting back toward the scolex: 8, 36, 55, 101-102, 136, 161-162, 171, 254-255. That these are true chiasms of the lateral canals and are not the result of twisting of the worm is evident from the fact that the lateral nerve cords, while inclining somewhat toward the median line at the regions of crossing, do not follow the water tubes over to the opposite side

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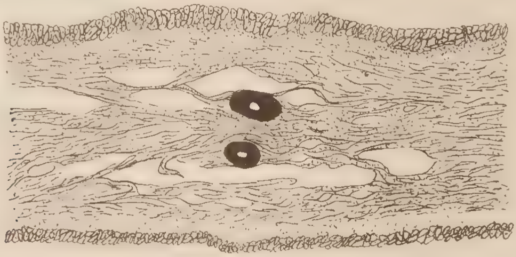
* From the Department of Zoology, Rutgers College.

(Fig. 3). In the smaller normal cysticercus transverse excretory canals are clearly evident in most of the segments, but in the larger specimen with the crossed lateral water tubes no transverse vessels are distinguishable.

Segments 98 to 106 containing the fourth chiasm were sectioned transversely in order to determine the relationship of the tubes at the point of actual crossing. As shown (Fig. A) the lateral canals are separated approximately 20μ from each other, there being no anastamosis. Each tube, surrounded by parenchyma, is as distinct from its mate as when occupying its normal lateral position. Examination of the remaining 7 chiasms by optical section shows that there is an appreciable distance between the canals where they cross. The distance separating the tubes at the chiasms renders it possible to follow the course of the channels from one end to the other and to determine which is above and which below in each case. Each tube is seen to be alternately above and below its mate, the two channels forming there-



Text Fig. A. Transverse section of chiasm showing the relation of the lateral water tubes at the point of crossing. Drawn with camera lucida. $\times$ 170.

fore a perfect elongated spiral of 8 turns. Since an even number of crossings occur, each tube ends up on the same side of the body on which it started. The number of segments occurring between respective chiasms, is as follows, beginning at the anterior end: from terminal bladder to first crossing, 8 segments; first to second, 28; second to third, 19; third to fourth, 46; fourth to fifth, 34; fifth to sixth, 25; sixth to seventh, 9, seventh to eighth, 83; eighth to scolex, 228 segments.

In addition to the abnormalities observed in the excretory system, there occur near the eighth chiasm a number of abnormal proglottids similar to those reported by Child (1900: 224) for Monezia, and illustrated in his figure 9. Segments 219-226, 228, 234, 236, 256, and 257 of my cysticercus show at one side of the segment the beginning of a secondary division which varies in length from a mere indentation to a definite furrow extending from the margin to a point just median to the lateral water tubes. No such secondary furrows are present in

the smaller cysticercus. These furrows occur upon only one side of the segment, there being no indication of the spiral arrangement of such abnormal furrows as reported by Child (1900, II) for Monezia.

No rudiments of genitalia were found by Linton in four specimens of *C. fasciolaris* obtained by him from the muskrat. His largest individual was 30 cm. long. In both of my specimens rudimentary gonads are present, being much better developed in the smaller individual. In this latter cysticercus, which contains some 223 segments, the reproductive organs are first evident in segment 25 and continue in well defined stages as far back as segment 87, after which they rapidly fade away (Fig. 4). The larger specimen shows rudiments of gonads in the first segment immediately behind the terminal bladder and these structures continue posteriorly to the 214th. segment. The rudiments are small, stain but lightly, and at no point do they approach in size and staining capacity the rudimentary genitalia of my smaller specimen.

Leuckart (1886: 355) states that *C. fasciolaris* is an exception to the majority of cystic worms in that early eversion of the rostrum occurs, but that the segmented body of this larva does not enter into the strobila of the adult any more than does any other bladder worm body. If this be true it is surprising to find such prominent rudiments of genitalia, as well as the definite excretory and nervous systems present in my specimens.

Interest centers about possible ways in which the lateral water tubes of the larger cysticercus might have become twisted into a spiral of 8 turns. The fact that these structures are intertwined in a definite spiral rather than being overlapped leaves open no interpretation other than that the twisting must have occurred before strobilation of the neck region was begun. Were the nerve cords also crossed with the water tubes it might be possible to explain the abnormality as being the result of torsion during the growth and strobilation of the larval cestode. With the lateral nerve cords where they are it is necessary to suppose that the water tubes grew out independently of the nervous system. Which of these two systems arises first in *C. fasciolaris* is not known. Tower (1900) claims that in Monezia the transverse nerve commissures appear before the proglottids are distinct. He finds the first traces of these behind the scolex, they being apparently the first of all proglottidal structures to be differentiated.

Abnormalities in the water tubes must be the result of variations in the process of their original differentiation in the neck region, as Child (1902) has pointed out in discussing the origin of abnormal proglottids in Monezia. One may suppose that following eversion of the scolex, before strobilation began, the lateral excretory tubes of the cysticercus grew out and established connection between the scolex and terminal bladder. At this stage the two trunks would be much closer

together than they are in the full grown larva. If during this period of outgrowth the trunks pursued the spiral course which they take in the region anterior to the scolex in the full grown cysticercus (Fig. 2) intertwining might occur as the result of an occasional increased amplitude of the spiral path. A spiral course of the lateral water tubes is apparently normal for this larva; Linton (1915: 47) noted the "sinuous marginal vessels" in his specimens. The absence of transverse water tubes in my abnormal cysticercus is probably connected with the twisting of the lateral trunks, though just what the relation may be is a matter of conjecture. It is possible that the suppression of the transverse tubes through some unknown cause during early differentiation of the neck region resulted in the lateral tubes growing in a wider spiral than would ordinarily be the case, thus increasing the chances of their intertwining.

The number of segments occurring between two consecutive chiasms varies from 9 to 83 with no regularity whatever, indicating that intertwining of the water tubes must have occurred solely as a matter of chance. Once the tubes established connection between the scolex and the terminal bladder, strobilation would carry the chiasms one by one away from the scolex as the cysticercus grew in length. Just how segments are formed in this larva is not known, but it may be assumed that they are separated off in regular progression from terminal bladder to scolex as in the formation of the strobila of adult Taenias. Should it be found subsequently that strobilation in this larva occurs after the intermittent manner described by Curtis for Crossobothrium, the above suggestion as to how intertwining might have occurred would still be valid. My hypothesis requires only that from the small part of undifferentiated neck region included between successive chiasms, the observed number of segments; 28, 19, 46, 34, 25, 9, and 83 should ultimately be formed in series.

The presence of abnormal segments in this cysticercus has been mentioned. The two segments immediately posterior to the eighth chiasm show a furrow on one side which extends from the edge approximately half way in toward the water tubes. Ten other segments showing the same abnormality lie some 20 segments anterior to the eighth chiasm. No abnormal segments occur in connection with the other 7 crossings of the excretory tubes, hence the presence of these abnormalities at the eighth chiasm is believed to be of no significance.

One distinctive feature to be noted at each crossing of the water tubes is the relatively narrower segments occurring at these points (Fig. 3). Such segments are from 0.3 to 1.05 mm. narrower than the average width of segments taken at the point on either side of the chiasms where the tubes, after crossing, again pursue a straight course. Expressed in percent decrease the above figures become 16 to 29%

Fig. 1.—*Cysticercus fasciolaris* and its cyst. The larger specimen, with crossed water tubes). Natural size.

Fig. 2.—Scolex and posterior end of smaller cysticercus. Note sinuous water tubes and lateral nerve trunks. × 16.

Fig. 3.—Chiasm of lateral water tubes at junction between two segments; lateral nerve cord above the chiasm. × 30.

Fig. 4.—Segments of smaller cysticercus showing rudimentary genitalia. × 16.

PLATE XI

respectively. The highest percentage decreases in width occur at the chiasms situated in the widest segments and vice versa, indicating that with displacement of the excretory tube from its normal path toward the median line as it approached the chiasm, the area drained by it to a less degree followed suit.

I wish to thank Dr. W. J. Crozier for suggestions and criticisms, and to acknowledge gratefully the aid of Dr. B. H. Ransom, of the Bureau of Animal Industry, in furnishing important references and for identifying the cysticercus.

SUMMARY

The lateral excretory tubes of a Cysticercus fasciolaris were found to form a spiral of 8 turns, covering some 243 segments.

The segments immediately adjacent to the chiasms are from 16 to 29% narrower than those on either side, suggesting that with medial displacement of the excretory tube at each chiasm the area drained by it became less. No transverse excretory tubes were demonstrated in this specimen.

Twelve segments out of 483 show secondary furrows upon one side of the segment only, there being no indication of a spiral arrangement of these abnormalities.

Rudimentary genitalia occur in this specimen and also in a normal cysticercus obtained from the same muskrat.

Intertwining of the excretory tubes must have occurred prior to differentiation of the neck region of the young cysticercus and may have resulted from an occasional increased amplitude of the sinuous path normally followed by the excretory tubes in this larval cestode.

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"OXYURIS INCOGNITA" OR HETERODERA RADICICOLA? *

J. H. Sandground

The discovery, by Kofoid and White (1919) in Texas, of an hitherto undescribed nematode ovum in the stools of a large number of soldiers, has been followed by similar findings in individuals in other parts of the United States as well as in other countries where, in the course of hookworm campaigns, extensive stool examinations have been made. The egg is described as being larger than that of any of the recognized intestinal worms harbored by man; its average dimensions are 95 by 40μ but these figures are subject to extraordinary variations, the length ranging from 68 to 133μ and the diameter from 33 to 43μ. The shape of the egg is characteristic, being marked by an asymmetry recalling eggs of the Oxyuridae. Another feature of the egg is the presence of two highly refractile hyaline bluish-green globules flattened asymmetrically at the poles of the embryo. They are sometimes combined in one large lateral or polar globule or are broken up into smaller moeities. These have been considered in the light of reserve food bodies. The resemblance that these eggs bear to those of the Oxyuridae has led the finders to assign them tentatively to the hypothetical *Oxyuris incognita,* pending the discovery of the adult organism. However, despite frequent attempts to remove the latter with various anthelminthics, the mother worm has not been found.

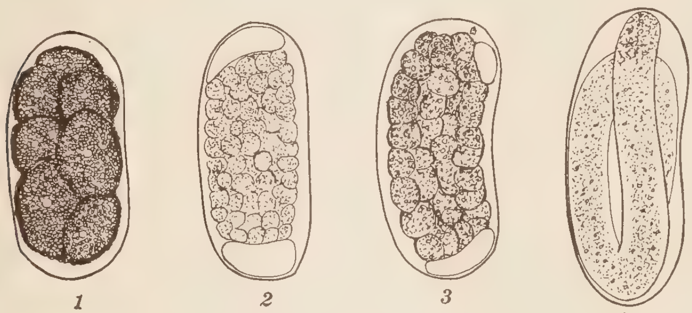
There are several anomalies associated with the finding of these ova. The fact that the eggs were found sporadically in the stools and that their occurrence was especially noticeable in the summer, a period when vegetable salads are a significant article in the diet, made it seem feasible to the writer that they originated in plant parasitic nematodes and were introduced with the food. Furthermore the morphological resemblance that exists between these eggs and the eggs of *Heterodera radicicola,* a very common root-parasitic nematode of universal occurrence in a great variety of plants including such root vegetables as radishes, celery, carrots, turnips, potatoes, etc., is also most striking.

An experiment was accordingly carried out to determine whether the eggs of *Heterodera radicicola* could be demonstrated in the stools after the ingestion of parasitized roots. Prior to the test, samples of the stools were carefully examined on a number of occasions but proved negative for all helminth ova. A few parasitized roots of beans (no other infested roots were available at the time) were then eaten together with other food and the meal was marked by means of charcoal tablets before and after eating. On the following day the stool was examined

* From the Department of Medical Zoology, School of Hygiene and Public Health, Johns Hopkins University.

and found to contain numerous Heterodera eggs. They were slightly brown in color and were in all stages of development, with the metameres so sharply defined as to indicate their viability (Fig. 1). They might full well be taken for eggs of an intestinal nematode parasite. The eggs could not be found on subsequent stool examinations.

The eggs of *Heterodera radicicola* are usually symmetrically ellipsoidal but vary somewhat in shape. They are frequently kidney shaped, especially when viewed laterally, and may also contain small fat globules (Stone and Smith, 1898; Sandground, 1922). Their size corresponds very well with the eggs of *Oxyuris incognita,* the length ranging from 62 to 128μ and the width from 33 to 43μ, but these limits might even be extended in different host plants.



1 2 3 4

Explanation of Text Figures

Figs. 1, 3 and 4 drawn with camera lucida.

Fig. 1.—*Heterodera radicola* egg as recovered from stool after ingestion of parasitized roots. Actual size 85 by 38μ.

Fig. 2.—Diagram of egg of *Oxyuris incognita* after Hegner and Cort (1921).

Fig. 3.—Egg of *Heterodera radicicola* from celery roots showing polar globules. Actual size 88 by 38μ.

Fig. 4.—Egg of *Heterodera radicicola* from celery roots showing fully developed embryo. Actual size 100 by 36μ.

The fact that these eggs can pass through the human alimentary canal, apparently uninjured, is of some interest to parasitologists since their presence in stools might be regarded as an indication of a nematode infestation. It also suggests the errors that might arise from describing a parasitic worm when only the ova are to be found. The eggs retrieved from the stools on the present occasion differ somewhat from the diagram (Fig. 2) of Hegner and Cort (1921). In the first place they did not show the marked flattening on one side and secondly no prominent globules were present. At the time I considered that these latter might be products of degeneration formed in the egg as a result of its passage through the digestive system or that they were elaborated in the process of cooking to which infested vegetables are often subjected.

However, I have since found in eggs from parasitized roots that were kept for a time in dilute alcohol, large fat globules frequently appearing in the form of polar globules (Fig. 3). The appearance of these eggs in every respect was indistinguishable from eggs of *Oxyuris incognita,* diagnosed as such by a worker associated with the original describers at the time of the announcement of the find. Another point which I think to be of sufficient significance *per se* to decide the question is the fact that in one of these eggs the embryo was fully developed and coiled in its shell in such a way as to leave a portion of the anterior end visible. In this embryo it was an easy matter to observe the esophagus and esophageal bulb which corresponded with those of the larva of *Heterodera radicicola.*

The suggested identity of the egg of *Heterodera radicicola* and *Oxyuris incognita* would furthermore very satisfactorily explain the sporadic appearance of the eggs in the stools as well as other anomalies presented by many cases of infestation with the hypothetical parasite and a consideration of all the above mentioned similarities convinces me of this identity.

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THE OCCURRENCE OF DIPLOPODS IN THE HUMAN ALIMENTARY TRACT

WITH NOTES ON TWO NEW CASES

RALPH V. CHAMBERLIN

In view of a widespread scepticism that persists as to the possibility of myriopods adapting themselves for any considerable length of time to a parasitic life within the human body, it seems desirable to preface the record of a new case with some general remarks. The scepticism mentioned is natural since so many supposed cases of this kind have been based upon observation not rigorously controlled and because of the well known tendency among persons, particularly women, in morbid or hysterical states to introduce organisms or other foreign material into their dejecta or even into the rectum or vagina. However, the number of carefully authenticated cases is now so large that there is no room whatever for doubt that myriopods may live for considerable periods, in some cases certainly for months, if not years, both in the aerial passages and in the alimentary tract, through the entire length of which they may pass unharmed.

The cases on record at the time were carefully reviewed by Professor Blanchard in 1898, with additions in 1902. Of the forty cases noted, thirty-one concerned the presence of the animals in the aerial passages, particularly the nasal cavity, and nine their presence in the alimentary tract. All the forms noted as occurring in the aerial passages were chilopods, these being active nocturnal forms that probably entered the body of their own volition during sleep; while of the forms noted as occurring in the alimentary tract, six are chilopods and three diplopods. In considering the likelihood of the continued living of myriopods once introduced into the stomach it should be noted that they are not disturbed by the higher temperature existing and that the digestive fluids do not act on their chitinous shell. The closing of the spiracles would prevent the penetration of the digestive fluids when the animals were submerged. These animals have been proved experimentally to be able to withstand long continued submergence, though in the stomach complete submergence would not necessarily be frequent or prolonged. The gases normally present contain enough oxygen to meet the needs of these forms and food would be abundant. In this connection it is interesting to recall the finding by Koenike (1889) of a living geophilid, determined by Latzel as *Geophilus sodalis* Bergsoe and Meinert, in the albumen of a hen's egg from Westphalia. In view of the nature of the special fertilization processes in myriopods, it is highly improbable that

reproduction could take place in the body, and the evidence indicates that the existence of the animals in numbers is due to repeated introductions. The cases are all to be regarded as examples of pseudo-parasitism.

It is the three authentic cases of the presence of diplopods in the alimentary tract that are concerned especially here. They may be briefly summarized. Dr. Tourtual, of Münster, was called in 1821 by a peasant woman twenty-eight years of age who suffered for three months of nausea, vomiting and cramps at the stomach. All medicines proved ineffective. The patient became exceedingly thin and weak, and kept herself doubled up on the couch, with hands compressing her stomach. Oedema of the limbs appeared, the vital forces seemed almost exhausted, fainting spells were frequent and various other symptoms indicated the approach of death. She complained of a living animal in her stomach whose movements were perceptible. Tourtual, thinking of a verminous affection, gave an emetic. In less than two minutes, in the presence of the physician, violent vomiting occurred. In the midst of the mucus was found a living Julus. This was a tailed form, listed as *J. terrestris,* but possibly also either *J. ligulifer* or *Schizophyllum sabulosum.* The symptoms then ceased and the patient recovered with no recurrence of the trouble.

The second case was recorded by Rooms in 1885. A young boy of eleven years living in Bruges manifested a bizarre taste in the choice of his food. He became thin and was subject to various ill feelings and nervous crises, particularly during the night; he complained of violent pains and of a strange sensation of movement in his stomach and intestines. It was thought to be a verminous malady; a vermifuge produced an expulsion of some ascarides, but without any noticeable amelioration. All these symptoms abated in the fall and winter, but the succeeding summer, at a time coincident with the first attack, they reappeared in aggravated form. For three consecutive years the same phenomena alternated with a state of comparative health and well-being in winter. Helminthics were of no avail. In August of the second year the child drank a glass of gin in which had been put some crushed blooms of Artemisia. Then there appeared in the stools for the first time living myriopods which survived for several days as well as in air as in water. The same treatment was applied several times, always with the same result. The following winter the child appeared to be completely recovered, but the third summer the same troubles reappeared. One day the mother gave the child a double dose of the customary remedy; he was then seized with vomiting and diarrhea, when he expelled a considerable number of live myriopods from the mouth, nose and anus. For another month the treatment was continued, but with more moderation; at the end of this time all trace of the parasites had disappeared and from then on his recovery was complete and undisturbed. The

myriopod was identified by Professor Plateau as *Julus londinensis,* a species very common in Europe and also in the eastern United States. As Rooms suggested, it seems highly probable that the little patient had infested himself by eating fruits, etc., the choice of which was directed by an evident perversion of taste.

The third case was reported by V. Thébault in 1901. It concerns a seamstress, thirty-nine years old, living in the suburbs of Paris. About the first of November this woman was seized from time to time by fits of coughing, accompanied by irritation of the throat and nausea. For three or four days she suffered also with a very intense itching in her ears and particularly in the commissure of the vagina. The woman had few teeth and mastication was therefore difficult, but her digestion was good. At the time indicated she experienced violent constrictions of the stomach, severe headache and pains in her limbs, as well as acute feelings of suffocation during the night. She said she had sensations of a great weight in her stomach. There was no constipation and no diarrhea. On the day which preceded the expulsion of the parasite she had a violent stomachache which was succeeded by diarrhea, this evacuation being accompanied by glairy and bilious vomit, very green. At the same time she suffered uterine pains which she described as being as severe as those she had suffered at childbirth. At length the tenesmus ceased and she had a liquid evacuation, a veritable intestinal débacle, in the midst of which she found, to her great surprise, a living myriopod. With its expulsion there was an absolute cessation of the symptoms. The myriopod was an adult male of *Polydesmus complanatus* (L.), measuring sixteen millimeters.

In 1919 the present writer received from Dr. L. O. Howard of the United States Bureau of Entomology a milliped which Dr. E. R. Shilling of Columbus, Ohio, had transmitted for identification. This specimen, according to the history supplied by Dr. A. H. Seeds through Dr. Shilling, had been removed alive from the rectum of a lad sixteen years of age, residing in Hilliards, Ohio, after he had experienced an intolerable itching in the region concerned. The boy had previously been sick for about a year; but I have been unable to secure from his physician a clinical history that connects clearly the illness with the presence of the diplopod. It seems desirable, however, to place on record an additional milliped that seems to have demonstrated its ability to live in the alimentary tract of man with possibly deleterious effect on the host. The specimen was an adult male of *Diploiulus pusillus* (Leach) (=*Julus virgatus* Wood), a small form from 8 to 10 mm. in length which often occurs in decayed spots of fruits and vegetables. Although a native of Europe, it has long been established in the United States.

A second case came to my attention through Prof. C. A. Kofoid of the University of California who in October, 1922, transmitted to me

for identification a milliped with the following note: "It is of interest to us because it was reported to have been vomited by a woman who had been troubled with bloody vomit for some time. This condition is reported to have continued for a year and she is stated to have vomited three other small specimens which cannot now be obtained." While the complete clinical history of this case has also not as yet been released, the general biological interest warrants putting on record the name of another milliped that apparently may at times become parasitic in the human alimentary tract when accidentally introduced. The specimen in this case proved to belong to *Parajulus trivius* Chamberlin, a small species for this genus, reaching a maximum length of 20 mm. The species is common about San Francisco Bay, but has not been taken thus far outside of California.

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A CILIATE ENDOPARASITIC IN *STENOSTOMA LEUCOPS*

WM. A. KEPNER AND R. P. CARROLL
University of Virginia

In the pools about the University of Virginia are found many *Stenostoma leucops*. Each year these are collected in great numbers for a large class in general biology. Despite the fact that many specimens of this rhabdocoele have been studied each year in this manner, this is the first time that Stenostoma has been found infected with a ciliate. It is probable, therefore, that this is a rare parasite.

Moreover, so far as we have been able to determine, no such ciliate has been described as being parasitic in Stenostoma. Recently the senior author observed a ciliate that was endoparasitic within the endoderm of *Hydra grisea*. The Hydra's enteron presents, one would think, an attractive habitat for parasites. So likewise the enteron of Stenostoma is a region in which endoparasites should be able to establish themselves easily. Endoparasites might less readily establish themselves in the mesenchymal tissue of Stenostoma, for there is no coelom here. Moreover, the interstitial spaces of the mesenchyme are so small that one would not expect to find ciliates living within these spaces.

The parasitized Stenostoma, when first seen, had many oval, refractive bodies that seemed to be clinging to its endoderm. There were about 50 of these seen in the dorsal aspect of the Stenostoma (Fig. 1). At first these refractive bodies suggested unusually large droplets of chyle, but when pressure from the coverglass caused the Stenostoma to be somewhat compressed, some of these bodies left the region of the enteron and glided from place to place through the mesenchymal tissue of the worm. This movement of the parasites seemed most drastic. As they plowed their way through the mesenchyme, the observer could not help but be impressed with what seemed to be a very painful process for the host and yet the Stenostoma showed no signs of being disturbed. This became all the more remarkable when one saw the ciliates pass over and under and to the side of the cephalic ganglia and even in this case not causing the animal to show any signs of discomfort. Contact between foreign bodies and the cephalic ganglia, therefore, does not seem to produce pain in Stenostoma. This method of parasitization is, therefore, quite remarkable in that it has established itself not within a coelom, but within the mesenchyme.

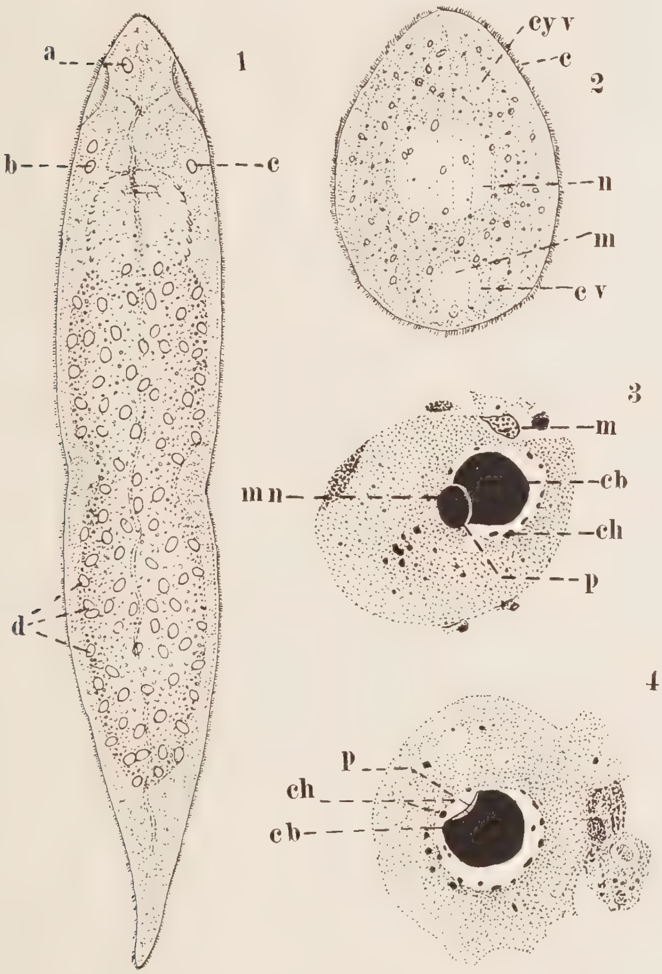
When these specimens were seen living within the host and moving to and fro within the mesenchymal boundaries, it appeared that they had fed upon much of the mesenchyme. But the sections of the Stenostoma show that these parasites had not destroyed the mesenchyme. They, therefore, must feed upon the food carried by the plasma that

fills the interstices of the mesenchyme. This plasma derives its food supply from the walls of the enteron. So when these ciliates are not disturbed they settle down as a swarm of quiet individuals about the outer wall of the enteron.

By means of pressing on the coverglass with a needle the Stenostoma was ruptured along the posterior left side of its body. Through this wound some of the parasites escaped. These freed animals proved to be ciliates, which were able to move about for some time outside the host. The body was oval, its axis being from 40 to 50μ long. It was densely ciliated. The cilia were quite short. Concentric myonemes ran lengthwise. The terminal mouth lacked pharyngeal rods and other membranes and was closed when the animal was not feeding. A large refractive, spheroidal nucleus lay near the middle of the body. At the posterior end of the body lay a contractile vacuole. A few other vacuoles were present within the cytoplasm (Fig. 2).

So much was obtained from the living material. The Stenostoma was next fixed 9½ minutes in chromo-aceto-formalin solution, sectioned in paraffin at 7 microns and stained in iron hematoxylin. The further study of the ciliates was made from the fixed material. There was considerable shrinkage of the parasites and the host's tissues. Despite this, good sections were obtained, showing the nuclear complex of the parasites. Here we found quite an unusual type of nuclear complex. Though the living specimens were seen under high objectives on all sides, no evidence could be had of the presence of a micronucleus. The refractive nucleus always presented an apparently unbroken spheroidal contour. In fixed material the nuclear complex displayed a three fold distribution of its chromatic material. The meganucleus had a definite nuclear membrane. Within the inner surface of this membrane lay numerous rod-like bodies of chromatin (Fig. 3, 4, *ch*). But the most conspicuous feature of this meganucleus was a large spheroidal chromatic body which lay eccentric (Fig. 3, 4, *c, b*). The third chromatic feature of the nuclear complex of this ciliate was the micronucleus. This is an oval to spheroidal body that lies deeply embedded within a pocket formed as an introvert of the membrane of the meganucleus. The eccentric position of the large chromatic body of the meganucleus stands related to the position of the micronucleus. In addition to this chromatic body has a concavity within which the pocket of the meganuclear membrane lies (Fig. 3 and 4, p).

Except for the unusual character of its nuclear complex, this animal could be considered to be a representative of the genus Holophrya of Ehrenberg. The departure of this animal, in its nuclear complex, from the generic type is not sufficiently great to warrant the creation of a new genus; but both its nuclear complex and its mode of living as an endoparasite warrant our assigning it to a new species. We have chosen to call it *Holophrya virginia.*



EXPLANATION OF PLATE XII

Fig. 1.—Dorsal aspect of *Stenostoma leucops. a,* endoparasite that had traveled over and anterior to the cephalic ganglia; *b,* an endoparasite lying to left of mouth; *c,* an endoparasite lying posterior to and right of the cephalic ganglia; *d,* the endoparasites clinging to the periphery of the enteron. × 50.

Fig. 2.—Dorsal aspect of an isolated *Holophrya virginia. n,* nucleus; *cv,* contractile vacuole; *cyv,* cytoplasmic vacuole; *m,* myoneme; *c,* cilia. × 1000.

Fig. 3.—Section of a fixed Holophrya virginia. *m,* mesenchymal cells of Stenostoma; *c b,* chromatic body of nucleus; *ch,* chromatin at inner surface of nuclear membrane; *mn,* micronucleus; *p,* depression in chromatin body of nucleus, within which lies the pocket of nuclear membrane that holds the micronucleus. × 15000.

Fig. 4.—Like Figure 3 except that the section did not include the plane within which the micronucleus lay; but the depression in the large chromatic body of the nucleus is shown, p. × 1500.

ON THE HABITAT OF *ASCARIDIA PERSPICILLUM* (RUD.) *

James E. Ackert

The work of Stewart (1917) in demonstrating that the habitat of ascarid larvae is not confined to the lumen of the small intestine but includes also the liver, lungs, trachea, esophagus and stomach raised the question of whether the larvae of *Ascaridia perspicillum* (Rud.), the large roundworm of chickens, also have this extended range of habitats. Accordingly, embryonated eggs of this nematode were administered to young chickens raised under controlled conditions, and after periods of from one day to two weeks the chickens were examined postmortem. Within 24 hours after feeding most of the eggs hatched and larvae were readily found in the duodenum and jejunum. The various organs were removed separately and opened in clean receptacles. The liver and lungs were either pressed between slides or teased, strained and the fluid centrifugalized. In this way a large number of chickens were fed and examined but in the great majority of the cases no larvae could be found outside of the intestine, a single larva in the lung of one chicken and a larva in the trachea of another constituting the positive cases of migrations up to 1920 as reported by the writer. Many subsequent feedings and postmortem examinations have been made with similar results except that two larvae were found in the liver of a chick. The early lung findings were confirmed by two positive cases among a large number of negative ones. The complete data which are to appear in another paper show that the small intestine, especially the duodenum and jejunum is the normal habitat of this nematode and that only occasionally are larvae of *Ascaridia perspicillum* found in the liver or other organs outside of the intestine of the domestic chicken. But the finding of an occasional larva of this nematode in the liver and other organs affords a possible explanation of the rare occurrence of more or less mature specimens of *A. perspicillum* in the spleen and ovary of chickens.

Recently in making a postmortem examination of a young chick that had been fed embryonated eggs of *A. perspicillum,* it was seen that the larvae were deeply imbedded in the intestinal mucus. On brushing the mucus aside and examining with the aid of a binocular microscope, the body of a larva could be detected in the wall of the intestine; and, between the larva and the objective, a blood capillary

* Contribution No. 66. From the Department of Zoology, Agricultural Experiment Station, Kansas State Agricultural College.

could be plainly seen. Further examination showed that the wall of the small intestine contained many partially imbedded larvae throughout a length of several inches. And each chick from this lot * examined subsequently had many larvae of *A. perspicillum* imbedded to a greater or less extent in the wall of the small intestine.

Portions of the fresh intestines containing the larvae were killed in corrosive sublimate and acetic acid, and sectioned. Examinatoin of the stained sections showed larvae in the spaces between the villi (Fig. 1) and down into Lieberkühn's glands, the anterior end usually being deepest in the intestinal wall (Fig. 2). The epithelium of the villi appears to yield readily to the invasion of the larvae, being frequently dented and sometimes apparently eroded. The method of penetration has not been determined, but that portions of the mucous membrane and axis of certain villi are destroyed is apparent both from the disappearance of tissues (Fig. 2, *a*) and from the presence of free blood in the lumen of the intestine where its walls were penetrated by the larvae. These severe infestations occurred in young chicks five to six weeks old and within seventeen days after the first feeding of embryonated eggs. A full report of studies on the penetration of the mucous membrane by the larvae, the length of their sojourn in the intestinal wall and other associated phenomena will be given in another paper.

In conclusion, the writer finds from the administration of embryonated eggs of *Ascaridia perspicillum* to young chickens and from postmortem examinations that the normal habitat of this nematode is the small intestine, especially the duodenum and jejunum, and that the larvae seldom inhabit the liver, lungs or other organs outside of the intestine; though two larvae were taken from the liver of a chick, seven from the lungs of three chicks and one larva from the trachea of another chick. This latter finding is suggested as a possible explanation of the presence of an occasional specimen of *A. perspicillum* in the spleen or ovary of the domestic chicken.

The writer also finds that after hatching in the chicken's small intestine, these Ascaridia larvae penetrate to some extent the wall of the small intestine, the body of the larva either denting the mucous membrane of the villi or destroying it, the anterior end occasionally extending through Lieberkühn's glands into the mucosa. Hence, the habitat of *A. perspicillum* includes the wall of the small intestine as well as its lumen.

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* Some of the chicks of this lot were used by Mr. C. A. Herrick, who likewise fed embryonated eggs of *A. perspicillum*. The writer wishes to acknowledge his indebtedness for the privilege of examining some of these chicks whose intestinal walls also showed partially imbedded larvae.

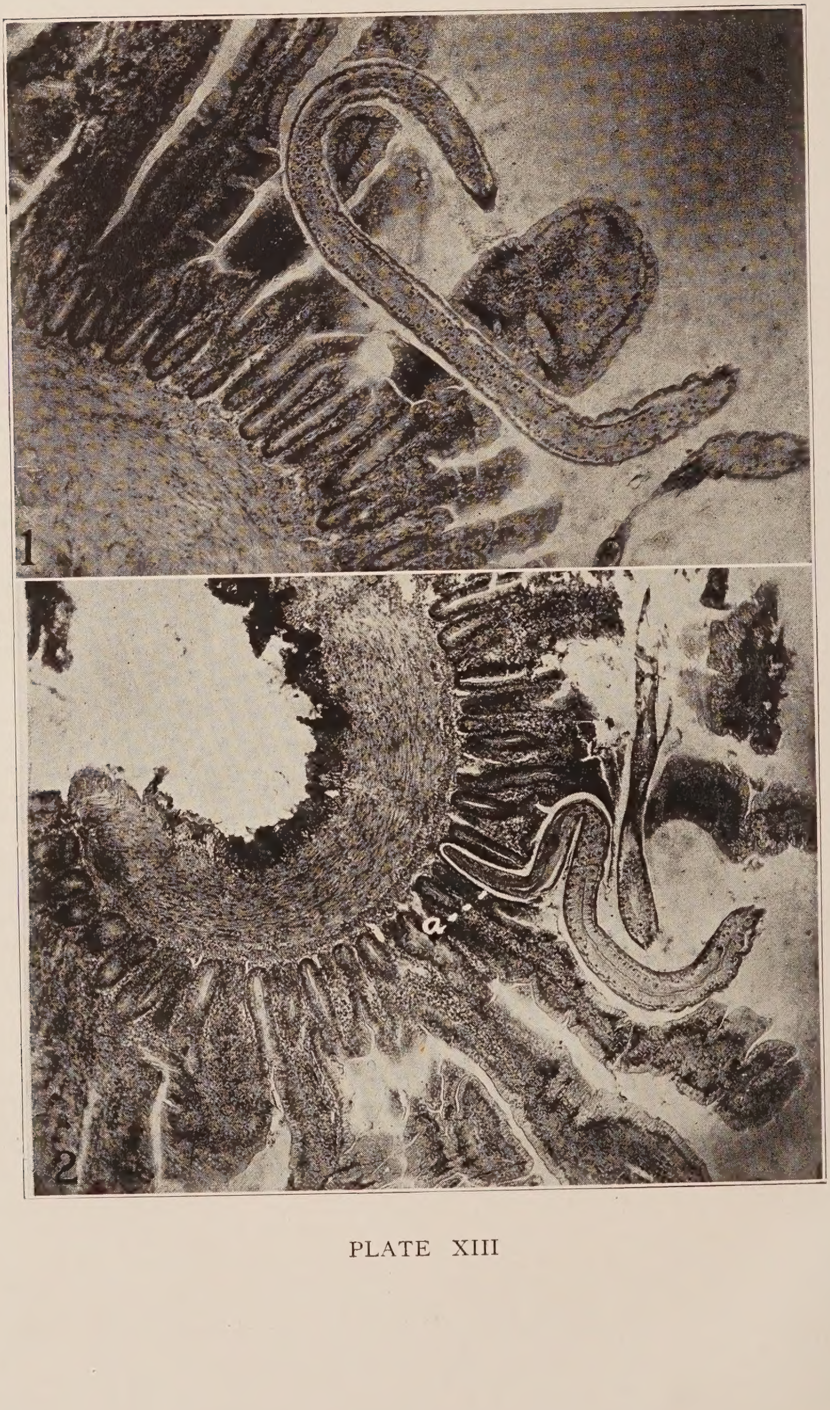

PLATE XIII

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Explanation of Plate XIII

Photomicrographs taken by Mr. C. A. Gunns from sections 10μ thick.

Fig. 1.—Section through small intestine of young chick showing larva of *Ascaridia perspicillum.*

Fig. 2.—Section through the small intestine of young chick showing larva of *A. perspicillum* in wall of intestine, anterior end extending through Lieberkühn's glands into mucosa; *a*, disappearance of tissue.

BOOK REVIEWS

OUTLINES OF MEDICAL ZOOLOGY. By Robert W. Hegner, William W. Cort and Francis M. Root. The Macmillan Company, New York, 1923. 175 pp., 21 figures.

In their recently published Outlines, the authors have striven to give a brief textbook for students, physicians and public health officers. The work has grown out of courses in the new School of Hygiene and Public Health at Johns Hopkins University and has proved its merits through preliminary use there. The text is highly condensed but withal clear and reasonably complete though only 52 pages are devoted to Protozoa, 40 to worms and 64 to Arthropods. Methods of diagnosis and of study are emphasized; some good keys are included; a very well selected general list of literature is given, and special papers are cited under each topic. The illustrations are numerous, new and good. One can but marvel that so much has been brought within such a limited compass.

THE JOURNAL OF HELMINTHOLOGY, Edited by R. T. Leiper, and published from the Department of Helminthology, London School of Tropical Medicine.

This new Journal, to be issued in five bi-monthly parts during the year, is primarily for the prompt publication of original research by the staff and workers in the Department at the London School. To judge from the three parts already at hand this publication is destined to occupy an important place in helminthological literature. Mostly morphological in content, the articles include also data on life histories, on biological phenomena like quiescence and reviviscence in Nematoda and on taxonomy. The illustrations which are well drawn are abundant and the typographic work is excellent.

NOTES

Professor Seitaro Goto of Tokyo writes that "none of the Japanese parasitologists have been affected by the misfortune except Dr. Miyajima, whose house was burned down. The zoological building of this university (Imperial University, Tokyo), which is of brick, cracked badly and part of it is being taken down, but no serious damage has been done to its contents and the personnel are all safe. The central library and the buildings used by the faculties of law, economics and letters, as well as those of physiologial chemistry and pharmacology have been lost by fire which originated in the laboratory of physiological chemistry immediately after the earthquake. Very little of their contents have been saved, owing to the general disorder that ensued and the lack of necessary water, although those who were at the spots fought bravely. The central library which contained many works never to be obtained again and in which were deposited several memorial collections, including the working library of the Sancrit scholar, Max Mueller, is a great loss for the university, and it will take years to have a similar one again."

Dr. Asa C. Chandler has resigned from the Rice Institute to accept an appointment as head of the Helminthology Department of the School of Tropical Medicine at Calcutta, India. His entire time will be devoted to research, particularly in connection with hookworm disease. He will sail from San Francisco early in January.

CORRECTION

On page 54, Vol. 54, Vol. X, of this Journal, I inadvertently, and erroneously, referred to *Taenia capitallata* Rudolphi as a synonym of *Tetrabothrius macrocephalus*.

Edwin Linton.

University of Georgia.